GENETICAL STUDIES FOR AGRONOMIC AND QUALITY TRAITS IN INDIAN MUSTARD

[*Brassica juncea* (L.) Czern & Coss]

THESIS
SUBMITTED FOR THE DEGREE
OF

DOCTOR OF PHILOSOPHY

IN

GENETICS AND PLANT BREEDING

OF

BUNDELKHAND UNIVERSITY
JHANSI (U.P.)

2000

By

Rajeev Kumar Tripathi

DEPARTMENT OF GENETICS AND PLANT BREEDING
CHANDRA SHEKHAR AZAD UNIVERSITY OF AGRICULTURE & TECHNOLOGY
KANPUR – 208 002 (INDIA)

DEDICATED TO MY VENERABLE PARENTS

डा. आर. के. दीक्षित
प्रमुख वैज्ञानिक (तिलहन)
Dr. R. K. Dixit
Professor / Principal Scientist (Oilseeds)

Phone : 294641-45
294661-65 PBX 136
ग्राम : एग्रीवर्सिटी
Gram: **Agrivarsity**

चन्द्रशेखर आजाद कृषि एवं प्रौद्योगिक
विश्वविद्यालय, कानपुर - २०८ ००२
C.S. Azad University of Agriculture
& Technology, Kanpur - 208 002

Date : 29th Dec., 2000

CERTIFICATE

This is to certify that the thesis entitled "**Genetical studies for agronomic and quality traits in Indian mustard [Brassica juncea (L) Czern and Coss]**" embodies the genuine work of **Mr. Rajeev Kumar Tripathi** himself. He has worked under my supervision for more than 24 months, commencing from the date of his application for enrolment, for the degree of **Doctor of Philosophy** in Genetics and Plant Breeding.

Mr. Rajeev Kumar Tripathi has put in more than 200 days attendance in this department during this period.

[R.K. Dixit]
Professor / Principal Scientist
(Oilseeds)

ACKNOWLEDGEMENT

In the name of God, the Beneficent, the Merciful

I take this opportunity to express my extreme gratitude to my guide **Dr. R. K. Dixit** Professor / Principal Scientist (Oilseeds), C. S. Azad University of Agriculture and Technology, Kanpur-208 002 (U.P.) for his valuable guidance, continuous encouragement and moral inspiration throughout the course of investigation and preparation of the manuscript.

I am deeply grateful to **Dr. Kaliyan Singh** Ex-Vice Chancellor and **Dr. V. L. Kesharwani,** Dean, Agriculture Faculty, Bundelkhand University, Jhansi (U.P.) for granting me the permission and providing necessary facilities to carry out this facilities.

I am extremely grateful to **Dr. Ramesh Chandra** Vice Chancellor, Bundelkhand University, Jhansi (U.P.) for providing me facilities and good wishes during course present investigation.

I am grateful to **Dr. I.P.S. Yadav** Ex-Vice Chancellor, C. S. Azad University of Agriculture and Technology, Kanpur for providing me the opportunity for Ph.D. work and permitting **Dr. R. K. Dixit** Principal Scientist (Oil seeds) to guide me in the programme.

I will remain indebted throughout my life to **Dr. D. N. Singh** Head Division of Plant Physiology Biochemistry and Micro-biology, Indian Institute of Pulses Research, Kanpur; **Dr. G. P. Lodhi** Senior Forage-Breeder, Department of Genetics and Plant Breeding Haryana Agriculture University, Hissar and **Dr. O. P. Mishra** Ex-Principal, Government Constructive Training College, Lucknow, **Dr. Z. Ahmad** Professor and Head / wheat Breeder, C. S. Azad University of Agriculture and Technology, Kanpur for this valuable suggestions expert advice forthsight help, moral support and readiness, whenever needed during the entire course of investigation and the preparation of manuscript.

I am highly grateful to **Dr. S. S. Yadav** Associate Professor, Deptt. of Biochemistry; **Dr. Mahak Singh** Asstt. Economic Botanist / Oil Seeds and **Dr. S. P. Sachan** Ex-Breeder (R. & M.) and all staff members of section of oilseeds C.S.A. University of Agriculture and Technology, Kanpur for their untiring help during the course of investigation.

I have a special words of thanks to my friend **Dr. B. K. S. Pundhir (A.M.), Shri S. K. Prajapati** Lecturer (Agronomy), **Shri R. K. Tripathi** D.I.O.S., Bijnour, for his affection, encouragement and untiring help during the course of investigation.

I could not find appropriate words in the lexicon to accentuate my profound regard to my beloved Parents, uncle Major P.S. Tripathi, epitomes of love, for their immaculate and impeccable affection. Overflow with gratitude to my brother and sister-in-law, younger brother, sister and my wife for their affection, encouragement and moral support to make this dream materialized.

Tripathi 29/12/2K

Place – Kanpur

Date – 29th Dec., 2000

(*Rajeev Kumar Tripathi*)

CONTENTS

CHAPTER 1

INTRODUCTION

INTRODUCTION

Oilseed crops play an important role in agricultural economy in India. The major oilseed crops are groundnut, rapeseed-mustard, sesame, linseed, castor, safflower and niger and grown in an about 13 per cent of gross cropped area. The country has distinction of being the largest grower of oilseed crops and has reached to near self-sufficiency in edible oil production but still there is wide scope for increasing production to feed fast growing population of the country. Rapeseed-mustard hold the promise in this aspect as it has both horizontal and vertical growth during the last decade.

Rapeseed-mustard are major *Rabi* oilseed crop of northern India. It occupies a prominent position, next to groundnut, among the various oil crops grown in India. The total production under oilseeds has gone up from 5.23 million tonnes (1949-50) to 22.24 million tonnes (1997-98). (Hedge and Kiresur, 1999). In U.P. , the total area was 1.18 millions hectares under oilseeds with the production of 1.14 million tonnes during 1996-97 in which rapeseed-mustard occupied an area and production of 1.07 million hectares and 1.10 million tonnes, respectively. The state of Uttar Pradesh has the largest share and contributes about 20.1 per cent in area and 22.78 per cent in production of the country. However, the productivity is very low (944 kg/ha) in comparison to other rapeseed-mustard growing countries like Germany where it is 2600 kg/ha.

There are various oleiferous *Brassicas*, grown in India. Important among these are Indian mustard [*Brassica juncea*(L.) Czern and Coss], Toria *(Brassica campestris* var. toria), brown sarson (*Brassica campestris* var. brown sarson), yellow sarson (*Brassica campestris* var. Sarson) and Banarsi rai (*Brassica nigra*) . Out of these, Indian mustard [*Brassica juncea* (L.) Czern and Coss], popularly known as rai, gained importance on account of this being widely cultivated in almost all the growing conditions and eco-geographic regions in the country. Indian mustard is preferred for cultivation because of the fact that it has better resistance to biotic and abiotic factors.

The mustard seed is largely crushed for oil, which is perhaps the cheapest source of energy in our diet and is mainly used for culinary purposes in Indian homes. The oil serves as a rich source of energy in predominantly vegetarian diet consumed in the country. The oil cake is used for cattle and manure. The species has an ability to grow rapidly and produces a considerable yield of vegetative material within a short growing period. For this reason, it is used as a companion crop with some legumes and cereals for feeding livestock.

Indian mustard is mostly grown as timely as well as and late sown crops. About 40 per cent of the total crop in the country is occupied under late sown irrigated conditions. These crops have been found to suffer from terminal heat stresses and also poor grain filling. Therefore, it becomes necessary to produce such varieties, which thrive reasonably well under late sown situations. There are some reports in the literature which suggest that yield and heat tolerance are controlled by separate genetic entities (Blum, 1974). Breeding, thus, requires identification of definite heat tolerance attributes and their transfer into high yielding and agronomically acceptable cultivars.

By and large, the studies in Indian mustard have been conducted under normal sown conditions and very little work has been done under drought and late sown situations. Hence, there is an urgent need to examine the nature of genetic variability for the physiological characters responsible for terminal heat tolerance, a phenomenon of late sown crop, through hybridization between genetically diverse strains, since selection for such physiological attributes has not been adequate so far.

Inspite of the fact that Indian mustard is an important oilseed crop specially in northern part of the country, the basic genetic informations needed for scientific breeding programme are scanty. Meagre research work has so far been done on the genetics of its economic attributes, as a result of which the breeding work has been confined mainly to conventional methods. The limited improvement, however, is due to narrow genetic base, and arbitrary choice of the parents for hybridization. Informations on gene action, nature and magnitude of the variance, heritability, genetic advance and genetic correlations which help in deciding the most appropriate and pragmatic breeding programme are very necessary.

While going to increase the genetic potentialities of any crop, the most complex problem facing the breeder is the judicious selection of the parents from the gene pool. This is because the yield is a complex character, comprising a number of components, each of which is polygenically controlled and, therefore, very susceptible to the environmental fluctuations. It is also desirable that selection for suitable parents involved in a hybridization programme should be based on the ability of a line to nick well with other lines and produce superior genotypes, For this purpose, the breeders use different biometrical approaches like diallel, modified diallel, partial diallel and Line x tester mating design for selecting the suitable parents through estimation of variances and effects. Line x tester analysis, as proposed by Kempthorne (1957), seems to offer scope for testing a larger number of lines for combining abilities and other genetic parameters of breeding value related to productivity.

There is an agreement amongst breeders that interactions between genotype and environment have an important bearing on the breeding of better varieties. However, it is such more difficult to find an agreement as what one ought to know about the genotype-environment interaction and what one should do about them. Some breeders emphasize the camouflaging effect of such interaction on the "value" of the genotype. Consequent upon they attempt to estimate the magnitude of variances attributable to interaction and to utilize such estimates in developing over more precise method of selection. Other breeders feel that improvement in efficiency are unlikely as only "final" characters such as yield is considered. Still others maintain that what is needed is a direct and pragmatic approach which will tell us what types of genetic systems are likely to give high and stable performance.

To identify desirable genotype which would be adaptable to a wide array of agro-climatic situations where the crop is grown differ from state to state and even within the same state. In most of the crop improvement programmes in India, normal and late sown testings for yield and other characters is being adopted to judge the adaptability performance of the lines. It also helps in developing varieties, which minimize genotype-environment interactions.

Keeping in view the fact that scanty research work has been done in Indian mustard, the present investigation "Genetical sudies for agronomic and quality traits in Indian mustard [*Brassica juncea* (L.) Czern and Coss]"with 23 parents (20 females and 3 males) alongwith their 60 F_1s and F_2s generated by line x tester mating design was undertaken with the following objectives:

(i) ***to estimate the relative proportion of additive and non-additive genetic variances and to characterise the nature of genotype-environment interactions for yield and other characters,***

(ii) ***to estimate the combining ability effect in order to screen superior general and specific combiners,***

(iii) ***to workout herterosis over best parent and inbreeding depression,***

(iv) ***to estimate the heritability and genetic advance,***

(v) ***to estimate the genotypic and phenotypic correlations coefficients and***

(vi) ***to estimate the direct and indirect effects of different variables on seed yield.***

CHAPTER 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Indian mustard popularly known as rai, [*Brassica juncea* (L) *Czern* and *Coss*] is considered normally a self- pollinated crop although about 7.6 to 18.1 per cent natural out crossing is found depending on the population of pollen vectors (Labana and Banga 1984).

Singh (1958) classified Oleiferous *Brassicae* as rape seed *Brassica campestris* var. brown sarson (2n=20), *Brassica campestris* var. yellow sarson (2n=20) and *Brassica campertris* var. toria (2n=20) while *Brassica juncea* (2n=36) is amphidiploid having in its genetic system 'A' genome from *Brassica Campestris* (2n=20) and 6 chromosome complement of 'B' genome four *Brassica nigra*(2n=16) Indian mustard, popularly known as rai or Laha is a crop of ancient cultivation in the Indian mustard sub-continent. According to Sinkai (1928) and Vavilov and Bukrich (1929), Indian mustard originated in China from where it migrated through north - eastern India to the Indo- Genetic plains of northern India and westwards to Afganistan. Voughan *et al.* (1983) suggested that natural hybridization between *Brassica juncea* may have occurred in more than one geographical area. Singh *et al.* (1974) collected and studied 308 cultivars of *Brassica juncea* that belonged to four distinct geographical regions of India and found that all regions exhibited wide variations in the frequencies of cultivars falling in different characters constellations. Two extreme groups being the north east region of Assam and West Bengal and that of north - west region of Punjab.

A brief account of literature available on different aspects of present investigation has been reviewed as follows :

GENETIC ANALYSIS OF QUANTITATIVE ATTRIBUTES

Components of genetic variance :

Most of the character of economic importance are quantitatively inherited. They are governed by a large number of genes, each with small effects and are characterized by continuous variation. They are also greatly influenced by environmental variations. A detailed knowledge about the nature and magnitude of genetic variation in a crop species is, therefore, essential for efficient breeding programme.

Galton (1889) intimated the use of statistic to biological problems. The study of inheritance of quantitative characters in plants began with the work of Johnson (1909), Nelson Ehle (1909) and East (1916). Theoretical basis of quantitative genetics was established by Fisher (1918), wright (1921) and

Haldane (1932). Fisher (1918) initiated the genetic analysis of quantitative characters. He partitioned the hereditary variances for metric traits into additive, dominance and epistatic components.

Wright (1933) also defined these components as (i) additive genetic variance, (ii) variance due to dominance deviation from the additive scheme, and (iii) variance due to deviations from additive scheme resulting from the interaction of non-allelic genes. Cockerham (1954) and Kempthorne (1955) further partitioned epistatic variance into factorial components of digenic and higher order interactions, such as additive x additive, additive x dominance, dominance x dominance of two loci situations and additive x additive for three loci and so on.

Schnell (1963) developed the expectations for partioning of genotypic variability into different components in the presence of linkage. The generalized equations, though very complicated, are extremely useful under such situations.

Gardner (1963) enlisted the following genetic parameters which are of interest to plant breeders :

(a) Additive variance ($\hat{\sigma}^2_A$) which results from the average effects of genes at all segregating loci.

(b) Dominance variance ($\hat{\sigma}^2_D$) which results from the inter-allelic interaction of genes at segregating loci.

(c) Epistatic variance which results from the inter allelic-interaction of genes at two or more loci and which is divisible into additive x additive ($\hat{\sigma}^2_{AA}$), additive x dominance ($\hat{\sigma}^2_{AD}$) and dominance x dominance ($\hat{\sigma}^2_{DD}$), for two locus situations, and additive x additive x additive ($\hat{\sigma}^2_{AAA}$) etc. for three or more loci.

(d) Average degree of dominance or ratio of dominance variance to additive genetic variance.

(e) Genotype x environment interaction which may be divided into additive gene effects x environment and non-additive gene effects x environment; and

(f) Genotypic correlations among quantitative characters for the particular crop.

In the present study, the genetic analysis was inferred from combining ability estimates over locations from line x tester mating design. A review of literature on this aspect is given below :

Concept of combining ability and its estimation :

The concept of combining ability was first given by Sprague and Tatum (1942). They recognised the combining ability of the classes i.e. general and specific combining abilities (gca and sca). According to them gca is the average performance of a line in hybrid combinations while sca is to designate those cases in which certain combinations do relatively better or worse than would be expected on the basis of the average performance of the line involved.

Henderson (1952) also defined gca as the average merit with respect to some traits or weighed combinations of traits of large number of progenies of an individual or line when mated with a random sample from some specified population under a specified set of environment conditions. The gca was defined as the "deviation of an average of an indefinitely large number of progenies of known gca these two lines or individuals and the material ability of the female parent". Gca is associated with genes which are additive in their effects. Sca on the other hand is attributed primarily to deviations from the additive scheme caused by dominance and epistasis (Sprague and Tatum, 1942). This fact is also apparent from the equations derived by Graiffing 1956 a):

$$2\hat{\sigma}^2_{gca} = \hat{\sigma}^2_A + 1/_2\, \hat{\sigma}^2_{AA} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\hat{\sigma}^2_{Sca} = \hat{\sigma}^2_D + 1/_2\, \hat{\sigma}^2_{AA} + \hat{\sigma}^2_{AD} + \hat{\sigma}^2_{DD} \ldots\ldots\ldots\ldots$$

Where, $\hat{\sigma}^2_{gca}$ is the variance due to gca, $\hat{\sigma}^2_A$ is the additive genetic variance and $\hat{\sigma}^2_{AA}$ is the additive x additive type inter-allelic interaction.

Similarly, $\hat{\sigma}^2_{sca}$ is the variance due to sca, $\hat{\sigma}^2_D$ is dominance variance, $\hat{\sigma}^2_{AD}$ is additive x dominance and $\hat{\sigma}^2_{DD}$ is dominance x dominance type of interaction.

Kempthorne (1957) proposed line x tester analysis which is analagous to Design II of Comstock and Robinson (1952). In this procedure, covariance of half-sibs and full-sibs were related to the variances due to general and specific combining abilities.

LINE x TESTER ANALYSIS :

The line x tester analysis has extensively been used for testing general and specific combining abilities of inbred lines. Kempthorne (1957) proposed a method in which a random sample of sires were taken, each of which was mated to each dam. He expressed covariance half-sib (Cov. H.S.) and covariances full-sib (Cov.F.S.) in terms of variances due to gca and variance due to sca. Thus the

method was employed for calculating the variances due to general and specific combining abilities.

NATURE AND NUMBER OF TESTERS IN EVALUATING LINES :

Matzinger (1953) defined a tester as "one that combines the greatest simplicity in use with maximum information on the performance to be expected from the tested lines when used in other combinations or grown in other experiment". No single tester can fulfill these requirements. Therefore, in such breeding programmes one has to keep a set of desirable testers to evaluate the lines efficiently.

Fedever and Sprague (1947) indicated that an increase in number of testers in many cases would have greater value than more extensive replication and the use of single tester.

Keller (1949) made a comparison involving the number and relationship between testers in evaluating the inbred Lines of maize and concluded that high and low combining lines were on an average of equal value testers.

Studies on the nature and number of testers were also made by Sprague (1946), Hull (1947), Burton (1948), Grogan and Zuber (1957), Burton (1959), Singh (1961), Vahtin (1962) and Singh and Joshi (1966).

In general, most of the workers agreed that for initial evaluation of large collection of inbred lines, more than one tester with good gca possessing high additive genetic components and others with broad genetic base should be used.

DEGREE OF DOMINANCE :

In polygenic inheritance, the effect of individual gene can not ordinarily be distinguished from one another. Consequently, it is not possible to determine the mode of action of each gene nevertheless, by studying their combined effects in segregating population, however, one can get some insight into their behaviour and can draw inference about the average level of dominance involved in the expression of a particular character.

Fisher *et al. (1932)* presented a method for estimating the degree of dominance and another basis for estimating the degree of dominance Comstock *et al.* (1949).

Dominance is complete, if "a" is equal to 1.0; value over 1.0 are associated with over dominance and value less than 1.0 with no or partial dominance is absent (Comstock *et al.* 1949). Further they gave the formula for "a" where it was

calculated as the ratio of mean square due to females and males. They have also demonstrated that unbiased estimates were obtained in the absence of interaction of non-allelic genes. Effects of epistasis which causes bias was removed by the method suggested by Horner (1952).

Comstock and Robinson (1948 and 1952) pointed out that it was theoretically possible to obtain estimates of over-dominance due to repulsion phase linkage in the material such as they used although the individual gene has expressed no more than partial dominance. Whether or not linkage has caused upward bias in the manner suggested by Gardner *et al.* (1953, 1959). According to them if average degree of dominance decreases in later generation them linkage is confirmed.

Mather (1949) pointed out that the ratio in which deviation of F_1 from mid-parent bear half the parent difference was frequently regarded as a measure of average dominance. Later this value of each cross was pooled over all the crosses in diallel analysis by Jinks and Hayman (1953) as $\sqrt{H_2 / D}$. This is the measure of dominance in Hayman's (1954 a) approach.

Robinson and Comstock (1955) coined pesudo over dominance as an upward bias due to linkage effects in the estimates of dominance variance in hybrid populations. In other wards, it is the magnitude of linkage bias in estimates of dominance in hybrid population and rate at which linkage is dessipated because of recombinations. Kempthorne and Currow (1961) calculated average degree of dominance as $\sqrt{\hat{\sigma}^2_s / \hat{\sigma}^2_g}$.

HETEROSIS AND INBREEDING DEPRESSION :

Heterosis :

The term heterosis was first used by Shull (1914), for the superiority in vigour of certain hybrids over parents. Hayes, Immer and Smith (1955) defined heterosis as increased vigour of F_1 over the mean of parents or over the superior parent. Abercrombie *et al.* (1961) described heterosis as increased vigour of growth, fertility etc., in a cross between two genetically different lines as compared with growth etc., in either of the parental lines associated with increased heterozygosity.

Initially hybrid vigour was observed by Koelreuter (1763) in artificial plant crosses. Knight (1799), Darwin (1877) and Focke (1881) described hybrid vigour in various crosses. Genetic basis of heterosis has been reported by East (1908, 1909), East and Hayes (1912) and string field (1950).

Whaley (1944) reported by hybrid vigour manifested the effect of heterosis and the two terms were synonyms. Gowen (1952) reviewed the researches directed towards explaining and utilizing the vigour of hybrids.

An understanding of the mode of action of heterosis has been resolved due to the study of the nature of gene action. Jinks (1955) suggested that non-allelic interaction is more likely and frequent cause of heterosis rather than specific relation between the genes at the same locus. Mather (1955) considered heterosis as an expression of genetic balance which depends upon adjustment and integration of polygenes. Jinks and Jones (1958) described it as a complex phenomenon depending upon the balance additive, dominance and interaction of homozygous / homozygous and homozygous / heterozygous components as well as on the distribution of genes in parental lines. Deskalov (1963) concluded that heterosis in F_1 is a combined expression of genetical, cytoplasmic, biochemical and physiological factors and may be attributed to stimulation, resulting from the interaction of different heritable factors of the parents in F_1. Turbin (1963) introduced the concepts of genetic balance which accounts, not only the interaction between hereditary factors but also the environmental factors.

Allard (1956), Bauman (1959), Dickinson and Jinks (1956), Hayman (1954b, 1963), Jinks (1954, 1955), Jinks and Jones (1958), Kempthorne (1956), Grafius (1959) and Eberhart (1964) demonstrated the correlation between heterosis and epistasis.

Robinson (1963) and Moll *et al.* (1964) suggested that genetic diversity of parental stocks and partial to complete dominance of the genes might be the major factor for heterosis in yield and component traits. Williams (1959), Durrant and Adams (1963), Grafius (1954) and Coyne (1965) explained that studies of individual component could manifest the genetic explanation of heterosis. Genetic basis of heterosis for complex character could be explained by multiplicative interaction at phenotypic level of the component traits. It was suggested that heterosis could possibly be explained on the basis of dominance rather than over dominance.

Inbreeding depression :

Darwin (1877) mentioned in his classical work "Cross and self fertilization in the vegetable kingdom" that offsprings arising from self fertilization were less vigours than those obtained from cross fertilization. East (1908) and Shull (1909, 1910) also observed decrease in vigour in subsequent segregating generations in self pollinated crops.

Wright (1922) showed that decline in vigour due to inbreeding was proportional to the heterozygosity. Jones (1924, 1939) observed inbreeding depression for various characters in a variety of species.

Heritability is an index of transmissibility of traits from parents to offsprings. The concept of heritability is important to determine whether phenotypic differences observed among various individuals are due to difference in their genetic make up or simply as result of environmental factors.

According to Lush (1940, 1943, 1949) the broad sense heritability is the ratio of total genetic variance to phenotypic variance. In narrow-sense, it is the ratio of additive genetic variance to phenotypic variance.

Robinson et al. (1949) defined heritability as additive genetic variance in per cent of total variance. They considered that additive genetic variance indicates the degree to which the progenies are likely to resemble the parents.

Smith (1952) described heritability as the ratio expressed in per cent of variance component due to additive fixable gene effects ($\hat{\sigma}^2_g$) to the sum $\hat{\sigma}^2_g$ + $\hat{\sigma}^2_D$ + $\hat{\sigma}^2_E$ where $\hat{\sigma}^2_g$, $\hat{\sigma}^2_D$ and $\hat{\sigma}^2_E$ are additive, dominance and environmental variances, respectively.

Several methods have been developed (Warner, 1952; Fry and Horner, 1957; Crumpacker and Allard, 1962 and Mather and Jinks, 1971) for estimation of heritability.

Genetic advance is still more useful estimate in selection programmes. Effective selection of genetically superior individuals requires the fulfillment of two conditions; (1) Phenotypic variation must be adequate in the original population, and (2) Heritability must be sufficiently high. In general as heritability and phenotypic variations increase, genetic advance through selection also increase. It is, therefore, necessary to utilize heritability estimates in conjunction with selection differential, which would then indicate the expected genetic gain from selection.

Lush (1940, 1943, 1949) emphasized the following breeding programmes on the basis of heritability estimation.

(i) When heritability, in narrow sense, is high, reliance should be placed mainly on mass selection or as heritability becomes lower, more emphasis should be placed on pedigree, sib test and progeny test.

(ii) If over dominance is predominant, the breeding plan should be towards inbreeding with the object of producing hybrids for commercial use.

(iii) If the epistatic variance is relatively high, more reliance should be placed on selection between families and line breeding.

(iv) If the variance due to interaction between heritability for correction and environment is relatively larger, the breeding plan tends more towards producing a separate variety for each ecological region.

(v) Heritability, in narrow-sense, may be used to estimate expected improvement due to selection.

According to Comstock and Robinson (1952), the genetic advance depends upon :

(i) The amount of genetic variability in base population.

(ii) The magnitude of masking effect of environment and interaction components of variability on the genetic variability, and

(iii) Intensity of selection.

Indirect Selection Parameters

Correlation Coefficient :

The knowledge of genetic correlations among economic characters and other traits helps to improve the efficiency of selection by use of favourable combination of characters and to minimize the retarding effect of characters that are negatively correlated.

Burton (1951) stated the usefulness of correlation studies in plant improvement and emphasized that estimates of correlation between various characters are of great value in planning and evaluating of the breeding programme of a crop.

Very often, it is observed that certain characters which can be noted during the period of growth of a plant, can be taken as a safe index for the yielding ability of that plant. Keeping it into consideration, knowledge of nature of association between yield and its components and between various components characters would be of great promise.

The elaborated elucidation of correlation was presented by Fisher (1918, 1936) and Wright (1941). Lush (1940) and Henzel (1944) have applied genetic correlation to animal breeding. Several workers such as Weber (1952) and

Johnson *et al.* (1955 a) in soyabean; and Miller *et al.* (1978) in cotton; Smith (1955) in wheat; Abraham *et al.* (1954) in poultry have reported genotypic and environmental correlation between different pairs of economic characters.

Joshi *et al. (1966)* advocated that a knowledge of genetic correlations between different characters that are economically important, is very essential for a plant breeder, if correlated response in unselected characters are to erode or nullify the again achieved by pains taking selection.

Genotypic correlation is the net effect of segregating genes that effect the characters, some causing the positive and other negative correlations. The major cause underlying such genetic correlations are pleiotropy, linkage and; developmentally relationships (Stebbins, 1950; Adams, 1967).

Path coefficient Analysis:

The path analysis was done as per Deway and Lu (1959), Ramanujam & Rai (1963) using the phenotypic correlations to assess direct and indirect influences of various components on grain yield.

Path coefficient may be defined as the ratio of the standard diviation of the effect due to a given cause to the total standard diviation of the effect due to a given cause to the total standard diviation of the effect i.e. if yield (Y) is the function or effect and x, (One of the various components, or causal factors of yield), the path coefficient for the path from x_1 to the effect Y is $\hat{\sigma}x_1/\hat{\sigma}_Y$.

GENOTYPE x ENVIRONMENT INTERACTION :

Genotype x environment interaction is the major factor affecting performance in many crops. A genotype can have different phenotypic expressions in varying environments or in micro and macro-environments [Comstock and Moll, (1963)] and or predictable and unpredictable environments [Allard and Bradshaw, (1964)].

The extent of interaction of genotypes with environments can be estimated from multi-environmental testings. Multi-environmental testing of varieties enable the breeder to estimate the genetic parameters more precisely.

Bradshaw (1965) found that expression of an individual genotype can be modified by the environment. The amount by which it is modified can be termed as its "plasticity" and there can be considerable inter-relationship among plasticities of different characters.

The genotype x environment interaction was observed important not only from the genetical and evolutionary point of view but also from agricultural production in general and plant breeding in particular (Breese, 1969).

Genotype x environment interaction is of major importance to the plant breeder in developing improved varieties. When the varieties are compared over a range of environments, the relative ranking usually differ which cause difficulty in demonstrating the significant superiority of a variety. Thus, reduces the genotype x environment interaction.

Stratification of environments has been used effectively. The region for which a breeder is developing improved varieties can often be so sub-divided that all environments in the sub-regions are some what similar. This stratification usually is based on such micro-environmental differences as temperature gradients, rainfall distribution and soil types.

Allard and Bradshaw (1964) suggested that heterozygous and heterogeneous population had the best opportunity to produce varieties which showed small genotype x environment interaction. They used the term "individual buffering" for individual members of a population show adaptability to a range of environments. They used the term "population buffering" to the variety which consists of a number of genotypes each adopted to somewhat different range of environments. Thus a heterogeneous population possessed population buffering.

Another term related to the performance of variety is adaptability. The adaptability of variety of genotype is generally assessed from interaction between genotype and environment (Allard and Bradshaw, 1964). Lewis (1954) defined phenotypic adaptability as "ability of an individual or population to produce certain narrow range of phenotypes in different environments". Adaptability is a genetic ability, which results in stabilization of the genotype x environment interaction by means of physiological and genetical reactions of an organism to environments.

In general, the two important consequences that arise from the genotype x environment interaction are (a) the performance of the genotypes is affected, (b) efficient and objective comparison of genotypes across the environments become problematic.

LITERATURE REVIEWED ON THE CROPS:

An attempt has been made to review the recent literature covering researches on Brassica sps. and other related crop in respect of the following aspects:

- (i) **Gene action, combining ability Genotype-environment interaction and degree of dominance**
- (ii) **Heterosis and inbreeding depression**
- (iii) **Direct selection parameters (heritability and genetic advance)**
- (iv) **Indirect selection parameters (correlation coefficient and path analysis)**

GENE ACTION COMBINING ABILITY GENOTYPE - ENVIRONMENT INTERACTION AND DEGREE OF DOMINANCE:

Kondra and Stefanson (1965) studied the inheritance of erucic acid content of rapeseed oil (Brassica napus) and investigation that erucic acid content is controlled by two gene pair system action in an additive manner.

Swamy (1970) studied nine divergent varieties of brown sarson for oil content of seed and observed that additive as well as dominant types of gene action were concerned in the control of this traits Dominances of both positive and negative effects of gene were apparent. He advocated that differential behaviour of dominance recessive relationship of the parents was probably related to their self-compatible or self-incompatible nature.

Tiwari and Singh (1973) reported that additive and dominance components were significant for days to flowering and plant height. Contrary to the finding of Tiwari and Singh (1973), they found that yield was mainly controlled by dominance component. Partial dominance was observed for days to flowering and over dominance for yield per plant.

Tiwari and Singh (1975) observed that variances due to gca were highly significant for grain yield, plant height and days to flowering while sca variances were significant for all the traits. They suggested that maximum yield of *Brassica Juncea* varieties might be attainable only with a system that can exploit both additive and non-additive genetic effects.

Yadav and Gupta (1975) recorded significant response for gca, sca and reciprocal effects for oil content.

Paul *et al.* (1976 b) studied the nature and magnitude of gene action involved in the inheritance of yield and some of its components in Indian mustard. They observed importance of both the additive and dominance gene effects in the inheritance of number of seeds per siliquae, number of siliquae per plant and number of primary and secondary branches but the contribution of

additive gene effect was greater than those of non-additive effects. Partial dominance was observed for number of seeds per siliqua, and number of siliquae per plant, number of primary branches and secondary branches, where as yield per plant exhibited no-dominance.

Ram *et al.* (1976) observed significant gca and sca effects for all the characters in *Brassica juncea* studied, viz; plant height, number of primary branches, number of secondary branches, length of siliqua, number of seed per siliqua and yield per plant and predominance of non-additive gene action was reported for all the attributes. However, a substantial amount of additive genetic variance was found for all the traits.

Lutfur (1976) studied in the F_1, F_2 and back cross population in *Brassica juncea* and observed that erucic acid was controlled by single gene pair with additive action.

Asthana and Pandey (1977) reported that seven traits were controlled by additive gene action in which days to flowering, number of secondary branches, number of siliqua on main receme and yield were predominantly controlled by additive gene action and plant height by both additive and non-additive type of gene action in Indian mustard.

Yadav *et al.* (1977) in *Brassica juncea,* observed that variances due to gca, sca and reciprocal effects were highly significant for seed yield of siliquae on main shoot, pod length, seeds per siliqua, main shoot length and number of secondary branch were conditioned by both additive and non-additive genetic variances. For plant height and primary branch number, additive variance was predominant.

Grami and Stefansson (1977), while working with summer rape, concluded that oil per cent was controlled by additive gene action, dominance was significant and epistasis was absent. Contrary to these finding, it was reported by Rao (1977) that oil content in brown sarson was conditioned by dominance gene action, while additive effects influenced plant height and siliquae set.

Labana *et al.* (1978 a) reported the importance of gca sca variances for all the six characters in *Brassica campestris.* The yield was predominantly controlled by non-additive gene action. They suggested that for increasing yield in synthetic varieties non-additive gene effects could be utilized in breeding programmes.

Labana *et al.* (1978 b) evaluated 30 lines of Indian mustard for general and specific combining abilities through line x testers analysis. Their results revealed that both additive and non-additive type of gene effects were equally important

for number of days flowering, where as for the number of primary branches, secondary branches and seed yield, the non-additive type of gene effects were predominant.

Anand and Rawat (1978) studied the inheritance of seed yield and its six principal components in the F_1 and F_2 for combining ability. The study showed significant variances of both general and specific combining abilities for the characters and estimated variance components revealed the predominance of non-additive gene action.

Chauhan and Singh (1979) in Indian mustard observed highly significant gca and sca variances for both F_1 and F_2 generations. The additive gene action was found more for days to flowering and maturity in both generations. For primary branches, non-additive gene action in F_1 and both additive and non additive gene action in F_2 were observed. The higher magnitude of $\hat{\sigma}_s^2$ and $\hat{\sigma}_g^2$ indicated over dominance for number of secondary branches, length of main receme, yield per plant, reflecting the importance of non-additive gene action.

Duhoon *et al.* (1979) reported that additive grene effects were relatively more important for number of days to flowering, number of secondary branches, plant height and non-additive effects were equally distributed in the control of number of primary branches in Brassica comparative(h) var. Yellow Sarson.

Paul (1979) in rape seed concluded the importance of both additive and non-additive gene action for control of primary and secondary branches, siliquae per plant and yield. Dominance (mainly of higher values) varied in degree ascending to combination, character and generation. Selection for high number of primary branches seemed to offer the best prospects for obtaining an increase in yield.

Bunson (1980) in winter rape (*Brassica napus*) advocated that gca variances were much higher than those of sca for all the traits studied. Reciprocal effects were significant four yield and days to flowering.

Mehrotra and Chowdhary (1980) indicated that additive gene action governed eight characters in Indian mustard which included number of siliquae and seed yield.

Pal and Singh (1980) reported in rapeseed that both the gca and sca variances were significant for the expression of all yield contributing characters. However, $\hat{\sigma}^2_s$ and $\hat{\sigma}^2_g$ indicated the preponderance of non-additive type of gene action for the characters. Nevertheless, reports were put forwarded by Govil

(1981) in Indian mustard which indicated that sca was more important then gca for seed yield and oil content.

Singh *et. al.* (1981) carried out genetic analysis on data from cross between *Brassica juncea* (L) varieties and observed that for yield, number of secondary branches, and number of siliquae on the raceme, over dominance gene effects were most important. Additive gene effects, although lower in magnitude, were also significant for these characters and predominant for days to flowering, number of primary branches showed equal importance of additive and non-additive components. Epistatic gene effects contributed to most of the character particularly those showing higher magnitude of dominance effects.

Yadav *et al.* (1981) emphasized the importance of both additive and non-additive gene effects in controlling the inheritance of oil content.

Yadav *et al.* (1981 b) in a line x testers analysis indicated that both additive and non-additive variances were important for the control of oil per cent.

Singh *et al.* (1982) estimated the components of variances and degree of dominance in Indian mustard and found that days to flower was controlled mainly by additive genetic variance. Where as the same was moderate for primary branch number. The magnitude of additive components was very low for secondary branches and yield per plant. Both these characters showed over dominance. Partial dominance was observed for primary branching and in complete dominance was observed for days to flower.

Dixit *et al.* (1983) reported that both additive and non-additive gene action influenced the inheritance of oil content.

Govil *et al.* (1983) studied genetic control of oil content in *Brassica juncea* (L.) and reported that both additive and dominance components of variation were highly significant in the F_1 and F_2 generations. The magnitude of dominance variance was much larger than that of additive genetic variance. Average degree of dominance tended towards over dominance.

Pal *et al.* (1983) observed that both additive and non-additive types of gene action were involved in the inheritance of oil content. They suggested that the dominant genes were responsible for higher oil content in *Brassica compestries* L. var. toria.

Kumar *et al.* (1985) tabulated the data on gca and sca for oil content in F_1 and F_2 generations involving 7 varieties . Five cross combinations which showed positive sca effects, were identified.

Chander *et al.* (1985) reported high value of gca for seed yield, number of secondary branches and plant height in Indian mustard. Parents showed highest specific combinations for seed yield, number of primary branches, number of siliquae on main raceme. RC 1268 was a good general combiner for most of the characters.

Singh *et al.* (1985) reported that both additive & non-additive gene effects were important for siliquae per plant and siliqua length in Indian mustard although non-additive gene effects were predominant. The *per-se* performance of parents was associated with their gca effects. Prakash and Laha 101 were best general combiners for seed yield. Most of the crosses showing significant sca effects involved both low x low or low x high general combiners. Singh *et al.* (1985) observed that variance due to gca and sca were highly significant for plant height, number of primary branches and secondary branches, days to maturity and seed yield.

Badwal and Labana (1987) revealed in Indian mustard the significant values both gca and sca variances for seed size, but sca variances was significant only for oil content and non-additive gene effect were important for two traits. For oil content and yield, sca variance were higher then gca variance indicating that dominance was predominant for these traits.

Badwal *et al.* (1987) reported that non-additive effects were predominant for all characters. Additive x environment interaction was more pronounced for seed yield than for other characters. Gca effects were positively correlated with parental performance.

Gupta *et al.* (1987) recorded additive gene effects for seed yield per plant and non-additive gene effect for number of primary branches and siliquae on main raceme in Indian mustard. The cross RLM-82 x Varuna showed significant desirable sca effects for seed yield, plant height and main shoot length, while the cross involving other females showed best gca effects for seed yield, plant height, main shoot length, primary and secondary branches and number of siliqae on main shoot. Kumar and Sinha (1987) reported the preponderance of additive gene effect for seed weight in rai.

Jain *et al.* (1988) determined the nature and magnitude of gene action governing the yield and yield components in *Brassica juncea.* Both additive and non-additive gene actions were predominant over additive and dominance effect with an important role of duplicate type of epistasis for most of the traits and suggested that for exploitation of additive and non-additive gene effects recurrent crossing can give desired results .

Hu (1988) intercrossed inbred lines of rapeseed (*Brassica napus* L.) to obtain a diallel set including reciprocals and seed oil content was examined. He found that partial dominance tended to increase oil content. *Badwal and Labana* (1988) observed that both gca and sca variances were significant for seed size, but sca variances was significant for oil content only.

Prakash *et al.* (1988) studies 24 F_2s, derived from 8 parents. The study showed that gca and sca variances were significant for oil content and yield components whereas sca variances were higher than gca for seed yield and oil content.

Gupta and Labana (1988) combined genetically diverse genotypes of *Brassica napus* in a diallel cross excluding reciprocals. They found that additive gene effects were involved in control of seed oil content. The parental varieties Ashai and Lores were singled out for the use in future selection programme.

Malik and Singh (1988) reported that out of 15 lines and their F_1 hybrids studied for 10 characters, BRA 929 x BCR - Hc_2 would be best for developing high oil yielding varieties.

Thakur *et al.* (1989) working on Indian mustard reported that mean squares due to genotypes, parents, crosses, lines, testers and line x testers were significant for most of the characters. The combining ability variances indicated the predominance of non-additive gene action for seed yield, primary branches and plant height whereas additive gene action for secondary branches, silliquae per plant and days to maturity.

Verma *et al.* (1988) studied the combining ability for yield, its components and oil content in yellow sarson and reported predominance of additive gene action for yield, primary and secondary branches per plant, silliquae on main shoot, and oil content, while it was non-additive for siliquae per plant. varieties YST 151 and PYS 6 were good general combiners for most of characters except 1000 seed weight.

Liv and Liv (1989) in *Brassica juncea* revealed that erucic acid was controlled by two pairs of additive genes with low dominance effects. Genetic behaviour of eruic acid fitted on additive dominance model with additive effect being predominant.

Podkolzina and Shpota (1989) while working on Indian mustard found that seed oil content was mainly controlled by non-additive gene action.

Gupta and Labana (1989a) studied additive dominance and epistatic components of variation for five physiological traits in F_2 of GSL 1 x Nikalis and Bronowashi x Topa in Brassica traits in F_2 of GSL1 x Nikalis and Bronowshi x Topa in Brassica napus. The dominance components and epistasis was important in cross Bronowashi x Topa.

Gupta and Labana (1989 b) further studies additive dominance and epistatic components of genetic variation for five yield related traits in Bronowashi x Topa and GSL1 x Nikalis in Brassica napus. Epistasis was important for seed yield and number of primary branches in Bronowashi x effects were predominant for all the traits except plant height in Brassica juncea, performance of parents was highly associated with their gca effects.

Singh and Srivastava (1986) in their study of half diallel cross analysis recorded that RL18 for seed yield and P 20/21 for oil content were best general combiners.

Jindal and Labana (1986) in Indian mustard found that additive and non-additive gene effects were equally important for all traits. Reciprocal differences were significant for all the traits except number of primary branches and days to maturity.

Kumar *et al.* (1986) reported that both additive and non-additive genetic component were operative for inheritance of free fatty acids and cross combinations were isolated possessing negative sca effects and suggested that selection in early segregating generations for high yield and low free fatty acid could be most appropriate for simultaneous exploitation of additive and non-additive genetic components.

Pal and Singh (1986) found that additive gene effects were important for days to maturity and days to flowering in Indian mustard.

Singh *et al.* (1986) through combining ability variance indicated the pre-pondrance of additive and additive x additive gene action for days to flowering, days to maturity, number of primary branches per plant, length of main shoot, whereas predominance of non-additive gene action was recorded for 1000 seed-weight secondary branches and yield per plant with small amount of additive gene effect in Indian mustard.

Kumar and Yadav (1986) worked out gca and sca effects for seven developments traits 21 F_1s involving eight parents in Brassica juncea grown in three environments gca effects were more important for most of the traits, but sca

effects were also significant gca, sca and reciprocal effects were all sensitive to environmental changes.

Chauhan (1987) studied combining ability analysis in 90 F_1s involving 20 parents in Brassica juncea. The variance due to gca and were highly significant for all the characters studied. The estimated components of variance revealed that additive component was predominant for days to flowering, plant height, number of primary branches while non-additive component of genetic variance important for days to maturity, secondary branches, siliquae length, seeds per siliqua, 1000 seed weight and seed yield.

Wani and Srivastava (1989) derived information on combining ability from data on seven characters in 23 lines of Brassica juncea and their F_1s and F_2s. They found that parents RK 8202, KR 5610, RK 1418, RH30, V10 and B 30 were good general combiners for seed yield.

Dhillon *et al.* (1990) in Indian mustard worked out seven agronomic traits viz; seed yield, primary and secondary branches, plant height and main raceme length. Gca and sca variances were important for all the characters evaluated though former was larger in magnitude than later except for seed yield. Variety RLM 198 was found the best general combiner for all the traits except seed size.

Varshney *et al.*(1990) observed high genotypic coefficient of variation for grain yield in F_1 population of toria. Low GCV was observed for this attribute in the elite stocks of B. *Campestris* and *Brassica juncea* but it was high in B.rougosa. It was positively associated with grain yield. Seed yield was the major contributor to variation for HI in three Brassica species. Non-additive gene action was prepondrant for seed yield.

Yadav *et al.* (1990) recorded that genetic control of seed yield was mainly through dominant gene effects and epistatic effect of the additive x additive and dominance x dominance type.

Pal and Kumar (1991) studied the type of gene action involved in the inheritance of oil content in Indian mustard. Findings revealed the presence of both additive and non-additive type of gene action. Recurrent selection might be used to exploit both types of gene action for improving oil content in Indian mustard.

Singh and Yashpal (1991) crossed seven *Brassica juncea* lines from India, four from the USSAR and one from Canada and developed 66 F_1s. Non-additive genetic variance predominated for control of oil content. RH 7859 was the best general combiner for oil yield followed by Kranti, RH 30 and Prakash.

Yadav *et al.* (1992) evaluated 45 experiments F_1 hybrids of Indian mustard alongwith 10 parents and studied that all the characters (seed yield, its component characters and oil content) were governed by both additive and non-additive genetic variances. Parents Varuna, Kranti RLC 1359 and RLC 1357 were identified as good general combiners earliness, siliqua length, seeds per siliqua, 1000 seed weight primary and secondary branches and oil contents.

Patel *et al.* (1993) crossed six lines of mustard viz RLC 1359, RC 1277, RH 7811, CSR 463, and RSK 2 with four testers. Viz; Varuna, Pusabold, Kranti and Krishna. Results indicated higher sca variances for all the characters suggesting predominance of non-additive gene action. RC 1277, CSR 164 and Kranti were good general combiners for yield, branches and siliquae per plant. The female parent RSK 2 and male parent Varuna had good gca effect for height and flowering. Six crosses showed significant positive sca effect for yeild. Two crosses whose parents were poor in gca but exhibited high sca effect in their cross combinations for seed yield.

Singh *et al.* (1996) reported high magnitude of variance for sca for days to flowering number of secondary branches and seed per siliqua, seed yield and oil content. However estimates of gca variance was high for plant height.

Varshney *et al.* (1997) reported that plant height was governed by two dominant gene in complementary pattern in brassica compestris.

Kumar *et al.* (1997) reported genotype x environment interaction in relation to combining ability. They observed the environment of both gca and sca variances for no. of siliqua on main fruiting branch and seed yield per plant Non additive variances was of greater importance that additive variance. Difference among the environment was significant for both gca x environment and sca x environment interaction variances were significant for these two characters, while further partioning revealed higher magnitude of non-additive x environment interaction then additive x environment for these two characters.

Choudhery and Sinha (1999) reported the importance of mutation breeding in Brassica juncea for obtaining variability in primary branch in main shoot and flowering they observed reduction in the number of primary branches and earliness.

Chauhan *et al.* (2000) reported significant differences, days to maturity in oil content in males and for all the characters in females except for secondary branches per plant and seed yield per plant.

HETEROSIS AND INBREEDING DEPRESSION:

A brief review of work done on Brassica species is given below:

Singh (1973) observed significant heterotic values for some F_1 hybrids for yield and certain crosses showed moderately high heterosis for the number of primary and secondary branches and recame length an average of 49 per cent in *Brassica juncea.*

Singh *et al.* (1975) in 16 hybrids, derived from 13 female parents and Appressed mutant and T 59 male parents; heterosis occurred for plant height primary and secondary branch number, siliquae per plant seed yield, the highest heterosis in the later compared to the better parental value being 200.45% and compared to the mid parental value being 240.97%.

Labana *et al.* (1975) found 76% heterosis for seed yield ranging from 21.0 to 25.5% for primary branches and lower values of heterosis for plant height and siliquae length in Brassica juncea.

Yadav and Gupta (1975) observed 14.46 to 7.07% heterosis over better parent for oil content in Indian mustard.

Amrithadevarathinan *et al.* (1976) reported high values of heterosis for parmary branches, secondary branches and siliquae on main shoot in a quantitative evaluation of intervarietal hybrids of Brassica campestris.

Gupta (1976) while working with Indian mustard reported 99.0% heterosis for seed yield.

Paul *et al.* (1976a) estimated highly significant heterosis value for primary branches, secondary branches, seed yield per plant and 1000 seed weight in *Brassica juncea.*

Yadav *et al.* (1977) observed heterosis for seed yield ranged from 13.9 to 239.0% over the better parental values.

Asthana and Pandey (1977) in their study on Brassica juncea observed high heterosis over mid-parent for seed yield, maximum 48.0% for number of siliquae on main recame and 19.0% for oil content.

Patnaik and Murty (1978) observed 42.5% heterosis for yield in brown *sarson.*

Suchuster *et al.* (1978) studied inbreeding and heterosis phenomenon in crosses made among diverse lines in black mustard (B. *Nigra)* and reported 203% heterotic values for seed yield, 123% heterosis for branching and little heterosis or no heterosis for 1000 seed weight and quality characters, though F_1s had high contents of oil. In case of inbreeding depression they found that mean depression relative to open pollinated sibs was 29% for seed yeild per plant, high for seed siliquae and branches per plant. For test weight, it was 4% and for plant height 7% but for oil content it was showing little amount of inbreeding depression.

Chauhan and Singh (1979) observed significant negative heterosis in a number of crosses than positive heterosis in most of yield contributing traits. They also reported inbreeding depression to be low for days to maturity, days to flower, seed per siliqua, high for plant height, secondary branches, 1000 seed weight and seed yield per plant.

Doloi and Rai (1981) studied inbreeding depression in nine elite rapeseed cultures for yield and its components under different form of selfing and reported that self incompatible group of culture showed inbreeding depression for days to flower, plant height, primary and secondary branches, siliquae per plant, seed per siliqua, yield per plant and 1000 seed weight either in S_1 and S_2 or in both.

Singh *et al.* (1983) in Indian mustard reported heterosis for yield in 27 crosses and heterosis for yield was mostly due to siliquae per plant, primary and secondary branches and siliquae length Six crosses showed high heterosis over better parent. All heterotic crosses involved low x low general combiners.

Anand and Rawat (1984) found significant positive heterosis for days to flower, plant height, number of primary and secondary branches, height, number of primary and secondary branches, seed per siliqua, yield per plant and oil content.

Banga and Labana (1984) studied F_1 hybrids from crosses between Indian and European lines. They found greatest hetero-beltiosis for seed yield per plant, number of siliquae on main shoot and number of secondary branches. The cross, RLM 514 x EJ2, showed greatest superiority in seed yield than the control variety.

Singh *et al.* (1985) observed that the progenies of eight crosses were superior to Indian x Indian cross progenies in number of siliqueae on main shoot, number of secondary branches and number of seeds per siliquae. Highest heterosis for plant height, seed yield and number secondary branches were recorded in RLK 78-6-1 x Pahadi <u>rai</u> (82.76%) and Pahadi <u>rai</u> x Blase (89.66%).

Indian x Exotic crosses, Varuna x Domo (84.4%) showed highest heterosis for seed yield.

Lefort-Buson *et al.* (1986) studies heterosis and reported a linear relationship between any of the indices. The relative efficiency of indices depended on seed yield character.

Lefort-Buson *et al.* (1987) reported that heterosis and F_1 performance differed among the crosses for all the traits. Heterosis was greatest when parental lines were unrelated and come from different geographical pools. About 50% of seed yield variation due to mean parental heterosis was explained by variation in kinship coefficient (I-Y).

Verma *et al.* (1989) reported significant heterosis effects over standard variety for days to flowering, primary and secondary branches per plant, 1000 seed weight, seed yield per plant and oil content. Hybrid PYS3 x PSY 6 gene the highest standard heterosis of 23.69% for seed yield in yellow sarson.

Dhillon *et al.* (1990) reported highest heterosis (113.6%) for seed yield in the cross RLM 198 x RK 2. Heterosis in yield was mainly attribute to increased branch number.

Kumar *et al.* (1990) found positive heterosis for seed yield primary branches, secondary branches, siliqua length and seed per siliqua.

Hirve and Tiwari (1991) observed highest heterosis over better parent for seed yield. They also observed significant (higher) heterosis for yield contributing characters. In most of the crosses, there was no inbreeding depression, but significant positive heterosis also showed inbreeding over selfing.

Rai (1993) reported that heterosis breeding is now being recognised as potent genetic tool for exploiting the presence of considerable amount of non-additive gene action inherent in the expression of the seed yield through the development of superior performing hybrids in *Brassicas*. The research work done in this direction has shown the existence of inbreeding depression varied from 12.1 to 25.6 (mean=14.6%). In the heterotic crosses made without using cytoplasmic male sterility in rape seed to show 4.9 to 24.6% (mean=12%) heterosis.

Patel *et al.* (1993) crossed six lines of mustard with four testers and found that only three crosses RC 1277 x Kranti (41.4%), RH 7811 x Kranti (27.9%) and RSK2 x Kranti (25.9%) has significant heterosis for seed yield over better parent.

Rai and Singh (1994) reported heterosis over the better parent and commercial check for seed yield oil content and some yield components in 28 inter varietal crosses of Brassica campestris. The average heterosis over better parents for seed yield and oil content was 21.3% and 32.0% respetively. Highest being 78.8% for seed yield and 11.4% for oil content while number of primary branches per plant exhibited 36.2%.

Singh *et al.* (1996) recorded heterosis over better parents in the tune of 77.6% for seed yield and 13.1% for oil content.

Varshney and Rai (1997) reported the pre dominance of non-additive genetic variance for 6 character, i. days to flowering, ii. days to maturity, plant height, number of primary branches, number of siliquae on fruiting branches and seed yield per plant in F_1 and F_2 generations.

Varshney and Rai (1997) observed highest heterosis over better parent for seed yield per plant (129.4%) and primary branch per plant (88.1%).

Chauhan et al. (2000) reported heterotic responses in single and three way crosses in Indian mustard from 25 single crosses and 12 three ways crosses. They observed highest heterotic response for seed yield followed by number of primary branches and secondary branches over better parent. When compared to standard check highest being 78.7% for seed yield.

Direct selection parameters:

Heritability:

The work done on the heritability and genetic advance in Brassica species by various workers is reported as under:

Singh *et al.* (1970 a) observed high estimate of heritability for plant height in B. campestris.

Singh *et al.* (1970b) in *Brassica campestris* estimated high heritability for days to flower and primary branches; lower for secondary branches and seed yield.

Singh *et al.* (1971) in yellow sarson found high heritability for days to flower, moderate for plant height and low for primary branches and seed yield per plant.

Singh (1972) observed high heritability for plant height low for siliquae on main raceme and seed yield per plant in Indian mustard.

Singh and Singh (1972) estimated high heritability for days to flower and plant height; whereas low heritability was reported for primary branches and secondary branches, length of raceme and yield per plant in Indian mustard.

Chauhan and Singh (1973) recorded high heritability for the days to flower, number of siliquae on main fruiting branch and plant height and moderate heritability for the number of primary branches and moderate genetic advance only for siliquae on main raceme and low for the plant height, days to flower and primary branches in Indian mustard.

Zuberi and Ahmad (1973) estimated relatively high value of heritability for seed yield; number of siliquae per plant and other yield components in *B. campestris* L. var. *toria.*

Katiyar *et al.* (1974) observed higher value of broad sence heritability as well as genetic advance for plant height and yield per plant in *Brassica juncea.*

Thurling (1974) found low expression of heritability for seed yield in rapeseed.

Rao (1977) observed high heritability values in brown sarson for type of branching; and days to flower. The expected genetic gain was highest, 60% and 75%, for type of branching and days to flowering, respectively.

Grami and Steffansson (1977) observed that the heritability was low for oil content in summer rape.

Wahhab and Bechyne (1977) estimated low heritability for oil content in Indian mustard.

Asthana *et al.* (1979) reported high heritability for oil content and the expected genetic advance was 3.14% in *Brassica campestris* L. var yellow sarson and 1.94% in *Brassica juncea.* Eight mustard and four sarson varieties showed significant improvement in oil content after three years of selection compared to unselected stock as vevealed by analysis based on single plant or plot bulk sampling or both.

Govil *et al.* (1980) advocated that in Indian mustard substantial improvement may be achieved by increasing oil content, seed yield or both through pendigree selection or biparental mating in advanced generations.

Labana *et al.* (1980) estimated the high values of heritability for seed yield in Indian mustard.

Pal *et al.* (1981) observed that heritability was high for number of primary branches and moderate for number of days to flower along-with high genetic advance for plant height in Indian mustard.

Yadav *et al.* (1981b) found higher heritability estimate for yield and earliness in Indian mustard.

Chaudhary and Sharma (1982) reported high heritability for number of primary branches per plant in Indian mustard.

Govil *et al.* (1983) reported higher values of heritability in F_1 than in F_2 generations for oil content.

Pal *et al.* (1983) studied heritability of oil content in rape seed and reported low heritability for this character. They suggested that recurrent selection could be used for improving oil content.

Wan and Hu (1983) observed high heritability values for flowering period primary as well as effective secondary branches. The highest expected genetic advance was reported for the number of days to flowering.

Yadav (1983) reported high heritability with high genetic advance for days to flowering in Indian mustard.

Gupta *et al.* (1985) reported high heritability 34.72% for oil content in Indian mustard.

Jindal and Labana (1985) recorded highest heritability 58.15% for oil content in Indian mustard.

Singh (1986) observed from his experiment in *Brassica* species in four environments and reported higher heritability estimates for secondary branches and number of seed per siliqua.

Banga *et al.* (1986) elucidated for nine characters of *Brassica* species that heritability estimates were high for flowering time, seed yield and plant height. For raceme length and number of primary and secondary branches, it was moderately high.

Kumar and Sinha (1987) examined inheritance of seed number in Indian mustard and recorded high heritability estimates.

Badwal and Labana (1988) found low heritability value (20%) for seed yield in Indian mustard.

Kumar *et al.* (1988) taken seven characters from 16 genotypes and recorded high heritabilities (64.3-93.7%) except yield (20.2%) as low. Heritability and expected genetic advance indicated a predominance of non-additive gene action for yield.

Hu (1988), while working on rape-seed *(Brassica napus)* found that heritability for oil content was estimated to be high 56.4%.

Podhllzina and Shopta (1989) while working on *Brassica juncea* found that heritbility for seed oil and erucic acid was low. To obtain high oil content free to erucic acid, recurrent selection and reciprocal inter-specific hybrids was recommended.

Chowadhary and Goswami (1991) recorded high heritability (Broad-sense) and genetic advance for number of siliquae per plant together with plant height.

INDIRECT SELECTION PARAMETERS (CORRELATION COEFFICIENTS AS WELL AS DIRECT AND INDIRECT EFFECTS.)

Mohammed *et al.* (1931) reported that yield per plant in *Brassica campestris* var. toria was positively correlated with the number of primary branches and 1000 seed weight.

Rai (1963) observed significant correlation of yield with days to flowering number of primary branches, number of secondary branches and number of siliquae per plant.

Quadri *et al.* (1966) observed positive and significant correlation between primary branches and secondary fruit bearing branches and negative phenotypic correlation was between number of primary branches and days to flower.

Seed yield positively and significantly correlated with number of primary and secondary branches, and number of siliquae per plant as reported by Chaudhary (1967) in *Brassica juncea* and Banerjee *et al.* (1968) in B. campestris var. yellow sarson.

Singh *et al.* (1969) in Indian mustard, observed seed yield was closely associated with number of primary and secondary branches and days to flower. They also observed strong associations between days to flower and number of primary and secondary branches, and concluded that these characters could easily be taken as criteria for selecting high yielding strains in Indian mustard.

Asthana and Singh (1973) in rai recorded significant correlation of seed yield with the plant height, number of primary and secondary branches and number of siliquae main recame.

Agrawal and Rai (1973) reported that seed yield, number of siliquae per plant and oil content showed positive and significant association with the oil yield.

Zuberi and Ahamd (1973) also reported total seed yield was correlated with number of siliquae per plant.

Labana *et al.* (1976) elicidated that palmitic acid content were positively correlated with stearic, linoleic and linolenic acid content and negatively correlated with oil content. Linoleic acid contents were positively correlated with oil content and linolenic acid was positively correlated with erucic acid contents . The erucic acid contents were negatively correlated with linolenic acid contents.

Rawat and Anand (1977) in *Brassica juncea* observed that at phenotypic level, yield and oil content were correlated with number of primary branches and day to 50% flowing. They further reported that yield was correlated with number of secondary branches,1000 seed weight and oil content.

Paul *et al.* (1978) in Indian mustard concluded from his study that seed yield per plant was significantly correlated with siliquae number per plant and with primary and secondary branch number.

Yadav *et al.* (1978) reported number of days to flowering was correltred with 1000 seed weight.

Labana *et al.* (1979) in *B. campestris* var. yellow sarson reported highly significant and positive correlation of seed yield with number of siliquae per plant.

Sudhaker *et al.* (1979) reported in *B. campestris* that grain yield was significantly correlation with number of primary branches and secondary branches, number of siliquae per plant and 1000 seed weight.

Yadav (1982) observed that seed yield showed significant positive correlation with number of primary and secondary branches, total siliquae number and days to flowering in rapeseed.

Varshney and Singh (1983) worked out the correlation of yield with other characters and reported that yield was positively correlated with primary branch number, siliquae per plant and 1000 seed weight.

Wan and Hu (1983) reported association of seed weight per plant with siliquae number per plant in rape.

Yadav *et al.* (1983) reported that 1000 seed weight and oil content were positively correlated with seed yield. However they also reported association of seed yield with number of primary branches, siliquae per plant and 1000 seed weight.

Singh *et al.* (1983) suggested from their studies that number of secondary branches and seed size be considered in breeding for increased yield.

Kumar *et al.* (1987) in yellow sarson reported that yield was highly correlated with number of secondary branches followed by primary branches, days to 50% flowering and plant height. Number of seed per siliquae showed high direct effect on yield.

Singh *et al.* (1987) **in** Indian mustard reported that seed yield was positively correlated with shoot height, siliquae per plant and primary and secondary branches per plant. The oil content showed significant and positive correlation with shoot height and 1000 seed weight.

Chowdhary *et al.* (1988) observed that yield that per plant showed positive and significant genotypic correlation with days to maturity, plant height, number of primary branches, number of siliquae on the main raceme, number of siliquae on lateral branches, siliquae length and 1000 seed weight. Number of primary branches had the highest positive correlation as well as direct-effect with yield in *Brassica juncea.*

Singh *et al.* (1988) recorded correlation coefficient between the characters siliquae length, siliquae per plant and primary and secondary branches per plant. The oil content showed significant and positive correlation with shoot height and 1000 seed weight, were positively and high significant except that between number of seed per siliqua and siliquae length in *B. compestris* var. toria.

Kumar *et al.* (1988) found the yield was positively and significant correlated with number of primary branches, secondary branches and siliquae per plant in Indian mustard.

Ahuja *et al.* (1989) reported oil content was positive correlated with that of erucic acid and observed negative correlation between linoleic acid erucic acid content (r = -0.71). Thus it was possible to evolve nutrionally improved toria cultivars with high linoleic and low erucic content.

Dhillon *et al.* (1990 b) in Indian mustard worked out high correlation with the length of main raceme, oil content and yield per plant, Number of primary branches was associated with number of secondary branches. The length of main raceme had a high correlation with number of pods on it and oil content.

Behl *et al.* (1992) reported phenotypic correlation coefficient of oil yield with siliquae per plant and seed yield were positive and significant in *Brassica juncea.*

Mendal *et al.* (1993) analysed the variation of the oil and yield level with in different germplasm lines as well as amongst five species of oileferous Brassicas and found that the oil and seed yield were negatively correlated.

Singh *et al.* (1996) observed positive association between oil content and seed yield indicating the possibility of simultaneous improvement of these characters.

Kumar *et al.* (1997) reported positive association between number of siliqua on main fruiting branch with seed yield per plant.

CHAPTER 3

MATERIALS AND METHODS

MATERIALS AND METHODS

MATERIALS :

The basic material for the present investigation comprised 23 parent (20 lines and 3 testers) of Indian mustard [Brassica juncea (L) Czern and Coss] selected on the basis of variability for various agronomic characters from the genetic stock maintained in the Section of Principal Scientist (Oil-seeds). Department of Genetic and Plant Breeding, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur-208 002 (U.P.) India. These parents had been maintained by selfing for several generations and, therefore, might be considered to be homozygous. The source, pedigree and salient features of these parents presented in Table 1.

Building up of material :

A set or 20 lines and 3 testers were sown during Rabi 1993-94 at Oil-seed Research Farm, Kalyanpur, Kanpur. These lines were crossed with each tester to obtain 60 F_1s. about 50 seed from each cross were sown and selfed at Palampur (H.P.) during Kharif 1994 for advancing the generation (F_2).

METHODS :

Experimental Plan :

During **Rabi** 1994-95, 23 parents, 60 each F_1s and F_2s. were sown in Randomized Complete Block Design with three replications in two environments viz., normal sowing (sown on 18.10.1994) and late sowing (sown on 8.11.1994) at Oil-seed Research Farm, Kalyanpur, Kanpur. All the treatments were grown in three rows plot in each environment.

Non-experiment rows were also kept in order to avoid the border effect. The length of each row was 3 m with inter and intra-row spacing of 45 cm and 15 cm, respectively in each environment. All the plots were applied recommended dozes of fertilizers (80 kg N+40 kg P+ 40 kg K/ha). One irrigation was given to the experiment in both the environments. Other recommended agronomic practices were also followed for raising crop in both the situations.

Recording of data :

Data were recorded on five randomly selected competitive plants of each parents and F_1s and ten plants in F_2s per replication for the following characters separately in both the environments:

(i) Days to flowering :

It was recorded as the period between seeding and opening of the first flower.

(ii) Days to reproductive phase :

Days to reproductive phase was the period between flowering to maturity of the siliquae.

(iii) Number of primary branches :

The number of first order branches designated as primary branches arising on the main shoot was counted on each tagged plant when the flowering was completed.

(iv) Number of secondary branches :

The number of second order branches arising from primary branches were counted as secondary branches when the flowering was completed.

(v) Height of plant :

The height of plant was recorded in cm from base of the plant to the tip of plant.

(vi) Length of main fruiting branch :

The length of main fruiting branch or main receme (the main rachis of the receme) was measured in cm at the time of maturity.

(vii) Number of Siliquae on main fruiting branch :

All the siliquae on main fruiting branch were counted at the time of maturity.

(viii) Days to maturity :

Days to maturity was recorded as the period from seed sowing to ripening of siliquae in the randomly tagged plants.

(ix) Relative water content :

It was determined by the method of weatherly and Blatyer (1957). At 60 days interval, the fresh leaf samples were collected from the selected plants

and immediately transferred to laboratory where after cutting it in to small pieces with the aid of a blade, the weight was recorded (fresh weight). The leaves were then put in distilled water for 3 hrs and weight of the turgid leaf pieces was recorded (turgid weight). Finally, these leaf pieces were put in an electric oven at 100^0C for 24 hrs and dry weight was recorded. Relative water content was then recorded by the following formula :

$$\text{Relative water content (in leaf) (\%)} = \left[\frac{\text{Fresh weight-Oven dry weight}}{\text{Turgid weight-Oven dry weight}}\right] \times 100$$

(x) Leaf water potential :

It was determined by using plant water status console (Model 3005) at 60 days interval. The fourth leaf from the base of each selected plant along with its petiole was taken and sealed in the pressure chamber with the cut surface of the petiole protruding. Pressure was applied to the leaf from a tank of compressed nitrogen gas until sap appeared on the cut surface. The amount of pressure that was applied to force water out of the leaf cells in to the xylem until it was refilled regarded as equal to the tension originally exiting in the xylem sap and approximately equal to the water potential of the leaf.

(xi) Yield per plant :

The total seed yield per plant was noted in gm by weighing the total seed obtained after threshing each plant separately.

(xii) Oil content per cent :

It was determined by using pulsed Nuclear Magnetic Resonance Spectrometer (NMR) technique for three randomly drown samples for each treatment in each replication in both the environments.

(xiii) Erucic acid :

Erucic acid content in oil was determined by GLC (Gas liquid Chromatograph) method. This instrument gave separation of major and minor fatty acid in the oil.

Statistical and biometrical analyses:

The experimental data were compiled by taking mean of all the observation of a treatment for all the three replications (environment wise as well as pooled) and was subjected to the following statistical and biometrical analyses.

ANOVA of Experiment:

The analysis of variance for the experimental design was based on the model.

$$P_{ijk} = u + v_{ij} + e_{ijk} \text{(where i, j. = 1 ....,t k = 1..........b)}$$

where

P_{ijk} = phenotype of the ijk the observation

u = population mean

v_{ij} = progeny effect

b_k = block effect

e_{ijk} = error term for ijk^{th} observation

On the model, the data obtained from the line x tester analysis of 60 crosses were subjected environment wise to Randomized Complete Block Design analysis on the mean basis separately for F_1 and F_2 generation. The skeleton for ANOVA is presented below :

Source	**d.f.**	**M.S.**	**F-test**
Replications	(b-1)	M_b	$M_b/M_e$for (b-1) (t-1) d.f.
Treatments	(t-1)	M_t	$M_t/M_e$for (t-1), (b-1) (t-1) d.f.
Error	(b-1)(t-1)	M_e	

Similarly, the skeleton for pooled ANOVA over both the environment separately for F_1 and F_2 generation in given under :

Source	**d.f.**	**M.S.**	**F-test**
Environments (En)	(en-1)	M_{en}	M_{en}/ M_e for (en-1). en(r-1) (e –1)d.f.
Replications (R)	(r-1)	M_r	M_r/ M_e for (r-1), en(r-1) (e-1) d.f.
Crosses (C)	(c-1)	M_c	M_c/ M_e for (c-1), en(r-1) (e-1) d.f.
(C) x (En)	(c-1)	M_{enc}	M_{enc}/M_e for (c-1), (en-1), en (r-1) (e-1) d.f.
Error	En (r-1)(c-1)	M_e	

Combining ability analysis :

The analysis of variance for combining ability was carried out environment wise as well as on pooled basis, according to the procedure suggested by Kempthorne (1957) separately for F_1 and F_2 generations.

The skeleton of ANOVA for combining ability for each environment is given below:

Source	d.f.	M.S.	F-test
Environments(En)	(en-1)	M_{en}	M_{en}/ M_e for (en-1). en(r-1) (mf -1)d.f.
Replications (R)	(r-1)	M_r	M_r/ M_e for (r-1), en(r-1) (mf -1) d.f.
Females (F)	(f-1)	M_f	M_f/ M_{fm} for (f-1), (f-1) (m-1) d.f.
Males (M)	(m-1)	M_m	M_m/ M_{fm} for (m-1), (f-1) (m-1) d.f.
(F)x (M)	(f-1)(m-1)	M_{fm}	M_{fm}/ M_e for (f-1), (m-1), en(r-1)(mf-1) d.f.
(F) x (En)	(f-1)(en-1)	M_{fen}	M_{fen}/ M_e for (m-1), (en-1), en(r-1) (mf-1) d.f.
(F)x(M)x(En)	(f-1)(m-1)(en-1)	M_{fmen}	M_{fem}/ M_e for (f-1)(m-1), (en-1), en(r-1) (fm-1) d.f.
Error	en(r-1) (mf-1)	M_e	

The model of Kempthorne (1957) was used for estimating the gca and sca effects in combining ability analysis separately for F_1 and F_2 generation. The model underlying this analysis is:

$$X_{ijk} = u + g_i + g_j + s_{ij} + e_{ijk}$$

where,

u = population mean

g_i = gca effect of the i^{th} male (tester 1,2.................m)

g_j = gca effect of the j^{th} female (line 1,2,..............f)

s_{ij} = sca effect of the i^{th} combination

e_{ijk}= environmental effect (error) associated with ijk^{th} observation.

$X_{ijk,}$ where, k= 1,2,...................r.

The individual effects were estimates with the help of following relationships.

Mean:

U= x ... / f_{mr} (where, X ... = total of all hybrid combinations.

Estimation of gca effects:

$\hat{g}_{im}$ = x_i .. /f_r - X .../ f_{mr} (where, x_i .. =total of i^{th} male parent (tester) over all females (lines) and replications.

$\hat{g}_{if}$ = x_j../ mr-X.../ f_{mr} (where, x_j.. = total of j^{th} female parent (line) over all males (testers) and replications.

Estimation of sca effects:

Standard error of combining ability effects were calculated as the square root of variance of effects as follows:

$\hat{S}_{ij}$ = x_{ij} / r - x_i.../ m_r - x_j../fr + X.../mfr.

S.E. (gca of males) or S.E. ($\hat{g}_{im}$) =(M_e/fr) ½

S.E. (gca of females) or S.E. ($\hat{g}_{if}$) =(M_e/m_r) ½

S.E. (sca effects) or S.E. ($\hat{s}_{ij}$) = (M_e/r)½

The significance of combining ability effects was tested by comparing with the values obtained by multiplying standard error of the corresponding effect with the table value of 't' at error degree of the freedom.

Genetic components :

Cov. H.S. (Line) = (M_f +M_{fm}/mr) mr

Cov. H.S.(tester) = (M_m x M_{fm}/fr)fr

Cov. H.S. (average)= [$^1/_2$ (efm- f-m) + { (f-1) M_f + (m-1) M_m/f+m-2}-M_{fm}]

Cov. F.S. = [(M_f -M_e) + (M_m-M_e) +(M_{fm}-M_e)/ 3 x r] + [6r Cov. H.S. -r(f+m) cov. F.S./ 3xr]

where,

Cov. H.S. = Covariance half-sib

Cov. F.S. = Covariance full-sib

M_f= mean sum of squares due to lines (females)

F_m = mean sum of squares due to tester (males)

M_{fm} = mean sum of squares due to line x tester

M_e = mean sum of squares due to error

$$\hat{\sigma}^2_{gca} = Cov.H.S.\left[\frac{1+F}{4}\right]\hat{\sigma}^2_A$$

And therefore,

$$\hat{\sigma}^2_A = 4Cov.H.S. : if\, F = 0 \; and$$

$$\hat{\sigma}^2_A = 2Cov.H.S. : if\, F = 1$$

$$\hat{\sigma}^2_{sca} = Cov.F.S. = \left[\frac{1+F}{2}\right] \quad 2\hat{\sigma}^2_D$$

And therefore,

$$\hat{\sigma}^2_D = 4\hat{\sigma}^2_{sca}, \; if\, F = 0 \; and$$

$$\hat{\sigma}^2_D = \hat{\sigma}^2_{sca}, \; if\, F_2 = 1$$

Degree of dominance:

The average degree of dominance was calculates as under using the formula suggested by Kempthorne and Curnow (1961).

Degree of dominance $= (\hat{\sigma}^2_D / \hat{\sigma}^2_A)^{1/2}$

where,

$\hat{\sigma}^2_D =$ Estimated variance due to dominant gene effects

$\hat{\sigma}^2_A =$ Estimated variance due to additive gene effects.

(a) Estimates of direct selection parameters:

Heritability:

Heritability estimates based on component analysis was calculated environment wise on the lines proposed by Kempthorne and Curnow (1961) as under: $\hat{h}^2 = [2\hat{\sigma}^2_g] / [2\hat{\sigma}^2_g + 2\hat{\sigma}^2_s + 2\hat{\sigma}^2_e] = [\hat{\sigma}^2_A] / [\hat{\sigma}^2_A + 2\hat{\sigma}^2_D + 2\hat{\sigma}^2_e]$

where,

$\hat{h}^2$ = estimates of heritability coefficient.

$\hat{\sigma}^2_g$ = estimate of variance component due to gca

$\hat{\sigma}^2_s$ = estimates of the variance component due to sca

$\hat{\sigma}^2_A$ =estimats of variance component due to additive of genes

$\hat{\sigma}^2_D$ =estimate of variance component due to dominance effect of genes

$\hat{\sigma}^2_e$ = expected environment component of variation

Heritability per cent in narrow sense = $\hat{h}^2$x100

However, for F_2 generation, the heritability coefficient was computed as follows: $\hat{h}^2 = \left(\hat{\sigma}^2_A\right)/\left(\hat{\sigma}^2_A + \frac{1}{2}\hat{\sigma}^2_D + \hat{\sigma}^2_e\right)$

And $\hat{h}^2(\%) = \hat{h}^2$x100

Heritability estimate in per cent over location based on different genetic values obtained from pooled analysis of combining ability was computed as under:

In F_1 generation:

$$\hat{h}^2 in\% = \left(\frac{\left[\left(\hat{\sigma}^2{}_A\right)\right]}{\left(\hat{\sigma}^2{}_A + \hat{\sigma}^2{}_D + \hat{\sigma}^2{}_{fen} + \hat{\sigma}^2{}_{men} + \hat{\sigma}^2{}_{fmen} + \hat{\sigma}^2{}_e\right)}\right) \times 100$$

In F_2 generation :

$$\hat{h}^2 in\% = \left(\frac{\left[\left(\hat{\sigma}^2{}_A\right)\right]}{\left(\hat{\sigma}^2{}_A + \frac{1}{2}\hat{\sigma}^2{}_D + \hat{\sigma}^2{}_{fen} + \hat{\sigma}^2{}_{men} + \hat{\sigma}^2{}_{fmen} + \hat{\sigma}^2{}_e\right)}\right) \times 100$$

where,

$\hat{\sigma}^2{}_{fen}$ = estimate of interaction component of variance due to females x environments

$\hat{\sigma}^2{}_{men}$ = estimate of interaction component of variance due to males x environments

$\hat{\sigma}^2{}_{fmen}$ = estimate of interaction component of variance due to variance due to females x males x environments

b) Genetic advance :

Genetic advance was computed using the formula proposed by Robinson *et al.* (1949) as given below :

Genetic advance (GS) = $k \times \hat{h}^2 \times \hat{\sigma}^2_{ph}$

where,

GS	=	expectation of genetic advance under selection.
k	=	selection differential at 5% selection intensity, i.e. 2.06
$\hat{h}^2$	=	estimate of heritability coefficient.
$\hat{\sigma}^2_{ph}$	=	phenotypic standard deviation.

Genetic advance in per cent of mean : GS (%) = (GS/$\overline{X}$) x 100

where,

$\overline{X}$	=	mean of the character concerned

Estimate of indirect selection parameters :

Correlation coefficients :

Phenoytpic and genotypic correlation coefficient between various character combination were calculated separately in F_1 and F_2 population, environment wise as well as on pooled basis using the following formula presented by Al-Jibouri *et al.* (1958).

i) Phenotypic correlation (r_{ph}) = $\left[\hat{\sigma}^2_{ph_{1,2}} / \hat{\sigma}^2_{ph_1} \hat{\sigma}^2_{ph_2}\right]$

where,

$\hat{\sigma}^2_{ph_{1,}}$ is the phenotypic covariance of the progeny means between two traits and $\hat{\sigma}^2_{ph_1}$ and $\hat{\sigma}^2_{ph_2}$ are the phenotypic variance of progeny means in first and second trait, respectively.

Test of significance :

The phenotypic correlation coefficient were tested with the following formula :

$$t = r/5 \,/\, \sqrt{1\text{-}r2} \text{ x } \sqrt{n\text{-}2}$$

The value of 't' was based on (n-2) degree of freedom, where, 'n' represented the number of treatment in the population concerned.

ii) Genotypic correlation (r_g) = ($\hat{\sigma}^2_{g_{1,2}} \hat{\sigma}^2_{g_1} \cdot \hat{\sigma}^2_{g_2}$)

where, $\hat{\sigma}^2_{g1,2}$ is the genotypic covariance between two traits $\hat{\sigma}^2_{g1}$ is the genetic variance of the first traits and $\hat{\sigma}^2_{g2}$ in the genetic variance of the second trait, the estimates of $\hat{\sigma}^2_{g1,2}$ $\hat{\sigma}^2_{g1}$ and $\hat{\sigma}^2_{g2}$ were obtained as follows :

$$\hat{\sigma}^2_{g1,2} = \left(\hat{\sigma}^2_{ph1} - \hat{\sigma}^2_{e1}\right)/r$$

$$\hat{\sigma}^2_{g.1} = \left(\hat{\sigma}^2_{ph1.2} - \hat{\sigma}^2_{e1.2}\right)/r$$

$$\hat{\sigma}^2_{g.2} = \left(\hat{\sigma}^2_{ph2} - \hat{\sigma}^2_{e2}\right)/r$$

where,

$\hat{\sigma}^2_{g1,2}$ = error covariance two trait

$\hat{\sigma}^2_{g.1}$ = error variance of the first trait

$\hat{\sigma}^2_{g,2}$ = error variance of the second trait

r = number of replications

In the formulae given, the ways to calculate the phenotypic and genotypic correlation coefficients between first and second characters has been given. In the similar manner, the correlation coefficients between all possible character combinations were worked out.

Estimation of heterosis :

The heterosis was calculated as increase or decrease in relation to best parent, the formula used are given below :

$$\text{Heterosis over best parent (\%)} = \left[\left(\overline{F_1} - \overline{BP}\right) / \overline{BP}\right] \times 100$$

where,

$\overline{F_1}$ = mean of the F_1

$\overline{BP}$ = mean of the best parent

Test of significance :

The significance of heterosis over best parent was tested by critical difference.

Critical difference (C.D.) :

The critical difference (C.D.) was calculated by the following formula :

C.D. = S.E. x t

where,

S.E. is standard error of the difference of the treatment mean to be compared and is equal to :

S.E. = $(2M_{se}/r)^{0.5}$

where,

M_{se}	=	error squares obtained from F_1 s only
r	=	number of replication
t	=	tabular value of 't' at 5% or 1% level of significance at error degree of freedom

Inbreeding depression :

The inbreeding depression observed in F_2 was calculated by the following formula :

i) Inbreeding depression (%) =$[\overline{F}_1 - \overline{F}_2) / \overline{F}_1] \times 100$

where,

$\overline{F}_1$	=	Mean of the F_1 generation
$\overline{F}_2$	=	Mean of the F_2 generation

Test of significance :

The value of C.D. was used testing the significance of inbreeding depression.

Estimation of direct and indirect effects (Path coefficient analysis:

The path analysis was done as per Dewey and Lu (1959), and Ramanujan and Rai (1963) using the phenotypic correlation to assess direct and indirect influences of various components on grain yield.

Path coefficient may be defined as the ratio of the standard deviation of the effect due to a given cause to the total standard deviation of the effect i.e. if yield (Y) is the function or effect and X_1 (one of the various components or causal factors of yield), the path coefficient for the path from cause x_1 to the effect Y is $\hat{\sigma}_{x_1}/\hat{\sigma}_Y$

The path-coefficients were obtained by solving a set of simultaneous equations of the form.

$$r_{ny} = P_{ny} + r_{n2}P_{2y} + r_{n3}P_{3y} \ldots.$$

where,

r_{ny} = correlation between n^{th} component character and yield.

P_{ny} = path coefficient between the n^{th} character and yield, and

r_{n2}, r_{n3} = etc stand for correlation between that character and each of other yield component in turn.

n = 1,2,………………….n i.e. various causal factors.

Considering all the simultaneous equations

Correlation matrices of the following form were prepared.

Matrix A		Matrix B		Matrix (P_{iy})	

$$\begin{bmatrix} r_{1.y} \\ r_{2.y} \\ r_{ny} \end{bmatrix}_{n\times1} \quad \begin{bmatrix} 1 & r_{1.2} & r_{1.3} & \ldots & r_{1.n} \\ r_{2.1} & 1 & r_{2.3} & \ldots & r_{2.n} \\ r_{n.1} & r_{n.2} & r_{n.3} & \ldots & 1 \end{bmatrix}_{n\times n} \quad \begin{bmatrix} P_{1y} \\ P_{2y} \\ P_{ny} \end{bmatrix}_{n\times1}$$

Such that, $A = (B) \times (P_{iy})$

The solution for the vector 'P_{iy}' (path coefficients) was obtained by multiplying both sides by inverse of 'B' matrix i.e. B^{-1}, Thus,

$$P_{iy} = (B^{-1}) \times (A)$$

The indirect effects of a particular characters through other characters were obtained by multiplication of direct path and particular correlation coefficients between those characters respectively.

Indirect effect of j^{th} character through i^{th} = $Y_{ij} \times P_{iy}$

where,

$i = 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 12$

$j = 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 12$ and

$P_{i.j} = P_{1.y}, P_{2.y}, \ldots\ldots\ldots\ldots\ldots\ldots P_{n.y}$

The undefined factors i.e., the variation in yield unaccounted for causal effects under consideration were designated by x. The path value of residual factor (x) in the following manner :

Residual factors (x) = $1 - R^2$

where,

$$R^2 = P_{iy}r_{iy} + P_{2y}r_{2y} + P_{3y}r_{3y} + \ldots\ldots\ldots\ldots\ldots\ldots P_{ny}r_{ny}$$

R^2 is the squared multiple correlation coefficient and is the amount of variation in yield that can be accounted for by the yield component characters.

CHAPTER 4

EXPERIMENTAL FINDINGS

EXPERIMENTAL FINDINGS

The data obtained from the present investigation for 13 attributes namely, days to flowering, days to reproductive phase, number of primary branches, number of secondary branches, height of plant, length of main fruiting branch, number of siliquae on main fruiting branch, days to maturity and yield per plant (component trait); oil yield (oil content x seed yield) and erucic acid (quality trait); two physiological characters, viz; relative water content and leaf water potential in two environments (normal and late sown plantings) were subjected to the following biometrical analyses and inferences drawn are described as under :

(i) Analysis of variance for the experiment.
(ii) Combining ability and its interaction with environments.
  a) Variance and variance components.
  b) Combining ability effects.
    1. General combining ability (gca) effects
    2. Specific combining ability (sca) effects
(iii) Selection parameters
  a) Heritability and genetic advance
  b) Correlation coefficients
  c) Direct and indirect effects (path coefficient analysis)

ANALYSIS OF VARIANCE FOR THE EXPERIMENT:

The analysis of variance for all the 13 characters under study was carried out for the F_1 and F_2 generations separately for both the environments (normal and late sown) including two physiological characters for testing the significance of differences among the crosses (treatments) in both the generations. The mean sum of squares for all the traits are presented in Table 2.

The 'F' test indicated that variances due to treatments were highly significant for all the 11 characters in both the environment. Significant differences were also observed among the treatments for two physiological characters in both the situations.

Analysis of variance for pooled data over two environments for 13 characters was carried out and the results are presented in Table 3.

The perusal of Table 3 revealed highly significant differences amongst the crosses in both the environments for all the 13 traits. Highly significant differences were observed for environments in both the generations for all the

13 characters. Interaction between genotypes (crosses) x environments was also significant at both the levels of significance for all the attributes in both the F_1 and F_2 generations. Interaction component was observed to be considerably high for all the traits in both the generations except erucic acid, days to flowering and number of secondary branches. Height of plant followed by days to maturity, yield per plant and length of main fruiting branch in F_1 and F_2 showed greater values for this interaction.

COMBINING ABILITY AND ITS INTERACTION WITH THE ENVIRONMENTS:

Variance and Variance components:

Line x tester data obtained separately for the F_1 and F_2 generations for each of two environments (E_1 and E_2, normal and late planting, respectively) were analysed and estimates for combining ability involving 13 characters were obtained. The estimates of mean sum of squares for females, males and females x males along with the components of genetic variances their magnitude and degree of dominance are presented in Table 4.

Data given in Table 4 indicated that the variances among the female genotypes were significant for days to flowering, days to reproductive phase, number of primary branch, number of secondary branch, height of plant, length of main fruiting branch, number of siliquae on main fruiting branch, days to maturity, relative water content, leaf water potential, yield per plant, oil content and erucic acid showed significant differences in both the generations as well as in both the environments. Significant differences were observed amongst the males for days to flowering, days to reproductive phase, number of primary branch, number of secondary branches, height of plant, length of main fruiting branch, days to maturity, leaf water potential, yield per plant, oil content in both the environments and generations; number of siliquae on main fruiting branch in E_1 and F_1 generation. Relative water content and erucic acid did not show any significant differences among the males either in date of plantings or generations. Females x males indicated significant differences for all the 13 attributes in both environments as well as in both F_{1s} and F_{2s}.

The components of variance which relate to the estimates of genetic variance of the population on viz; Cov (H.S.), Cov (F.S.), $\hat{\sigma}_f^2$, $\hat{\sigma}_m^2$, $\hat{\sigma}_{fm}^2$, $\hat{\sigma}_g^2$, $\hat{\sigma}_s^2$, $\hat{\sigma}_A^2$, and $\hat{\sigma}_D^2$, were worked out from combining ability analysis of variance for all the 13 characters in both environments and in both F_1 and F_2 generations. The findings are presented in Table 4. The ratio between additive and dominance variance ($\hat{\sigma}_A^2 / \hat{\sigma}_D^2$) and average degree of dominance i.e. $\left[\hat{\sigma}_D^2 / \hat{\sigma}_A^2\right]^{1/2}$ were also

worked out from the variance components. A ratio of 1:1 between $\hat{\sigma}_A^2 / \hat{\sigma}_D^2$ indicates the equal importance of both additive and dominance components of variance for the expression of a particular character, where as deviation from the 1:1 is indicative of the relative importance of either $\hat{\sigma}_A^2$ or $\hat{\sigma}_D^2$, depending upon the value .

Due to negative estimate of additive genetic component ($\hat{\sigma}_A^2$) in case of height of plant in E_2 of F_2, length of main fruiting branch in E_1 and E_2 of F_1, relative water content in both E_1 and E_2 as well as in both the generations, and oil content in F_2 of both date of plantings, the ratio of $[\hat{\sigma}^2_A/\hat{\sigma}^2_D]$ and degree of dominance $[\hat{\sigma}^2_D/\hat{\sigma}^2_A]$ ½ could not be computed.

The perusal of Table 4 revealed that the estimates of variance due to females were higher than the corresponding variance due to males for all the attributes in F_1 and F_2 generations at both environments. In general the variance component due to sca was considerably higher in magnitude than the corresponding genetic variances for gca in all the traits in both environments and in both F_1 and F_2 generations except erucic acid. The preponderance of sca variances indicated the importance of non-additive (non-fixable) gene action involved in the expression of these characters.

The estimates of average degree of dominance revealed that all the attributes exhibited over dominance both in F_1 and F_2 generations in both environments i.e.$[\hat{\sigma}^2_D/\hat{\sigma}^2_A]$½ was greater than one except erucic acid where the value was less than one reflecting partial dominance.

An evaluation of genotype in individual environment involved considerable deviation caused by genotype x environment interactions. Therefore, the data for all the 13 characters involving both planting dates (environments) were pooled separately for F_1 and F_2 generations. The pooled estimates of mean square due to females, males and females x males along with their interaction with environments (females x environments, males x environments and females x males x environments) are presented in Table 5. Estimates of genetic components on pooled basis namely $\hat{\sigma}^2_f$, $\hat{\sigma}^2_m$, $\hat{\sigma}^2_{fm}$, $\hat{\sigma}^2_{fen}$, $\hat{\sigma}^2_{men}$, $\hat{\sigma}^2_{fmen}$, $\hat{\sigma}^2_g$, $\hat{\sigma}^2_s$, $\hat{\sigma}^2_A$, $\hat{\sigma}^2_D$ along with the ratio of. $[\hat{\sigma}^2_A/\hat{\sigma}^2_D]$ and degree of dominance.$[\hat{\sigma}^2_D/\hat{\sigma}^2_A]$½ were obtained for both F_1 and F_2 generations separately. The findings on these aspects are given in Table5

The values presented in Table 5 reflected that the estimates of mean square due to environment, females, males and females x males along with their some of the interactions with environments were significant for all the characters both in F_1 and F_2 generating. The components of variance due to females were higher

than the corresponding components of variance due to males in number of traits in both the generations. The components of variance for females x males were comparatively higher than corresponding variance components due to females and males separately in number of characters in both the generation. However, when environments were taken into account, the estimates of variance due to females x males x environments were not higher than any other interaction components viz., females x environments or males x environments in most of the attributes under study. The variances due to sca ($\hat{\sigma}^2_s$) were higher in magnitude due to gca ($\hat{\sigma}^2_g$) for all the characters both in F_1 and F_2 generation indicating the importance of non-additive gene action. However, ($\hat{\sigma}^2_D$) was higher than ($\hat{\sigma}^2_A$) for all the characters except erucic acid in both the generations, where the preponderance of additive type of gene action was indicative in the inheritance of this character.

Table 5 also revealed that all the attributes reflected over dominance i.e., the ratio $\left[\hat{\sigma}^2_D / \hat{\sigma}^2_A\right]^{1/2}$ was greater than one in both the generations except erucic acid which indicated partial dominance because the ratio $\left[\hat{\sigma}^2_D / \hat{\sigma}^2_A\right]^{1/2}$ was less than one in both the generations.

General Combining Ability Effect:

The estimates of general combining ability (gca) effects for 23 parents (20 lines+3 testers) of individual environments and pooled over both the environments for 13 attributes in F_1 and F_2 generations are presented in Table 6. The lowest and significant values for gca were considered to be desirable for days to flowering, height of plant, days to maturity and erucic acid and for rest of the characters the highest positive and significant values of gca effects were regarded as guidelines to isolates the desirable general combiners. Based on these criterion, the results are described as under :

In F_1 hybrids, the desirable and significant gca effects were recorded for days to flowering in parents namely, RK 8605, RK 8604, RK 8602 and RK 8801 at both environments as well as in pooled analysis. In F_2 the parents RK 8605, Mathura Rai and Vaibhav indicated significant and desirable gca effects at both environments and pooled over environments. In both the generations two parents namely, RK 8605 and RK 8602 exhibited desirable and significant gca effects pooled over both the environments.

In case of days to reproductive phase, four parents namely, RK 9001, RK 911296, RK 14 and RK 8608 in both environments and on pooled basis in F_1 and F_2 generations reflected significant and desirable gca effects. Parents namely, RK 9001, RK 9, RK 911296, RK 14 and Vaibhav common in E_1 and E_2 in F_1

generation; RK 8608, RK 8602, RK 9001 and RK 911296 common in E_1 and E_2 in F_2 generation revealed significant and desirable gca effects.

For number of primary branches, the significant and desirable general combiners were RK 9001, RK 911296, RK 14, RK 8601 and RK 8902 in both the environments and pooled over environments whereas, RK 9001, RK 9, RK 911296, RK 14, RK 8608, RK 8903 and Vaibhav pooled over environments were good general combines in F_1 generation. In F_2, parents RK 9001, RK 911296, RK 9, RK 14, RK 8702, RK 8803 and Mathura Rai were good general combiners in both the environments and in pooled analysis.

In F_1 generation pooled over the environments, parents RK 9001, RK 918506, RK 14, KRV 47, RK 9002, RK 8604 and Laha 101 were exhibiting significant and desirable gca effects while parents RK 8902, RK 8602, RK 8608, RK 8605, RK 14 and Mathura Rai in pooled environments in F_2 generation reflected significant and desirable gca effects for number of secondary branches.

It was interesting to observe that on the basis of pooled over the environments and pooled over the generations, only one parent, RK 14, exhibited an excellent general combiner for this attribute and was worthy for its exploitation in further breeding purposes.

In Indian mustard, dwarf types were considered desirable for producing more number of secondary branches and more number of siliquae, ultimately resulting more seed yield with high oil content. Parents RK 8601, RK 8605, RK 9001 and RK 8702 were good general combiners on the basis of significant and desirable gca effects in both the environments and on pooled basis for dwarf types (shorter plant height). In F_1s parents, RK 8601, RK 8903, RK 9001, RK 8605 and RK 8702 common in both the environments were found to be significant and desirable general combiners whereas, parents RK 8601, RK 918506, RK8702, RK 14 and RK 9001 in F_2 and common in both the environments revealed significant and desirable gca effects.

For length of main fruiting branch, the significant and desirable general combners were RK 8608 and RK 8901, RK 8701 and 8702 common in both the generations pooled over the environments. Parents RK 8608 and 8801 pooled in F_1 and RK 8901, RK 8701, RK 8605, RK 8702 and Vaibhav pooled in F_2 revealed good general combiners.

Significant and desirable general combiners were recorded for number of siliquae on main fruiting branch in three parents common in both the environments and pooled over environments in both the generations. These were

RK 8701, RK 8901 and RK 8702. When individual generation was considered, 10 parents namely, RK 918506, RK 8801, RK 8606, RK 8701, RK 8901, RK 8702, RK 8802, Laha 101, RK 8803 and RK 8604 in F_1 and RK 8901, RK 8702, RK 8701 and Vaibhav in F_2 showed significant and desirable gca effects in the same order of ranking common in both the environments.

For days to maturity, parent KRV 47 in both the generations at both environments and on pooled basis had shown significant and desirable gca effects. Parents RK 8605, RK 8801 and KRV 47 in F_1 at both the environments; RK 8903, RK 14, RK 9002, RK 911296, KRV 47 and RK 9001 in F_2 at E_1; RK 8605, RK 8701, RK 8604, Vaibhav and RK 8601 in F_2 at E_2 were superior general combiners. However, none was found common in both the environments indicating inconsistency of estimates in days of maturity.

In case of relative water content, six parents namely, RK 8702, RK 9001, RK 8601, RK 8801, RK 8602 and RK 8604 exhibited significant and desirable gca effects at both the environments and on pooled basis in both the generations (F_1 and F_2). Nine parents viz., RK 8702, RK 9001, RK 9002, RK 8601, RK 8701, RK 8801, RK 8602, RK 8604 and Laha 101 at both the environments in F_1 revealed desirable general combiners while in F_2 parents, RK 8701, RK 8801, RK 8702, RK 8902, RK 8604, RK 8602, RK 8601, RK 8901 and Vaibhav common in both the environments exhibited significant and desirable gca effects. In both the generations and at both the environments the ranking of the desirable and significant parents were in the same magnitude as well as in ranking.

In F_1 and F_2 generations pooled over the environments, significant and desirable gca effects were recorded for leaf water potential in parents RK 8601, RK 9001 and Mathura Rai in both the generations at both environments and on pooled basis. Six parents each in F_1 (RK 8601, RK 8902, RK 8602, RK 9001, RK 8901 and Mathura Rai) and F_2 (RK 8601, RK 8702, RK 8903, RK14, RK 9001 and Mathura Rai) common at both the environments were superior general combiners indicating stability under both normal and late sowing environments.

In case of yield per plant, parents RK 8702, RK 911296, RK 8802 and RK 8701 showed significant and desirable gca effects pooled over both the environments and common in both the generations (F_1 and F_2) indicating stability in these parents for yielding ability over generations. Seven parents (RK 8902, RK 8702, KRV 47, RK 8901, RK 8801, RK 8604 and RK 9002) in F_1, eight parents (RK 8701, RK 9001, RK 14, RK 8702, RK 8608, RK 911296, RK 8604 and KRV 47) in F_2 revealed good general combiners common in both environments. They exhibited same order of ranking in both the generations at

both the environments reflecting stability in performance under both normal and late planting.

Significant and desirable gca effects for oil content were recorded in parents RK 8901, RK 9001, RK 8605 and RK 8604 which were common in both the generations pooled over environments. Among these parents, RK9001 and RK 8605, were common at both the environments in both generations and pooled analysis indicating high degree of stability in this character. In F_1s six parents namely, RK 8901, RK 8701, RK 8903, RK 9001, RK 8605 and Vaibhav; in F_2 eight parents namely, RK 9002, RK 8803, RK 8602, RK 9001, RK 8605, RK 911296, RK 8604 and Vaibhav common in both the environments revealed significant and desirable gca effects, indicating stability for this attributes under both normal and late sown situations.

In the case of erucic acid, parents RK 8801, RK 8903 and RK 8901 exhibited significant negative gca effects which were desirable, pooled over both the generations and both the environments indicating stability in these parents for this attribute.

Specific Combining Ability Effects :

The estimates of specific combining ability (sca) effects for each environment and pooled over both the environments for 13 attributes both in each 60 F_1 hybrids and F_2 progenies alongwith their mean performance are presented in Table 7. The criteria for sorting out desirable and significant specific combiners were the same, which was followed in case of gca effects.

Significant and desirable sca effects were recorded in 15 cases at normal sowing, 13 cases at late sowing and 7 cases on pooled basis for days to flowering in F_1 generation. Among these, the maximum sca effects, in order of ranking, were contributed in 10 hybrids at each environments namely, RK 8802 x Vaibhav, RK 8702 x Vaibhav, KRV 47 x Laha 101, RK 8608 x Laha 101, RK 9002 x Mathura Rai, RK 8604 x Mathura Rai, RK 8604 x Laha 101, KRV 47 x Vaibhav, RK 918506 x Vaibhav and RK 8608 x Vaibhav in E_1; RK 8802 x Vaibhav, RK 8702 x Vaibhav, KR 47 x Laha 101, RK 8604 x Mathura Rai, RK 8608 x Laha 101, RK 918506 x Vaibhav, KRV 14 x Laha 101, RK 9002 x Mathura Rai, RK 918506 x Laha 101 and KRV 47 x Vaibhav in E_2. In these cross combinations RK 8802 x Vaibhav, RK 8702 x Vaibhav, KRV 47 x Laha 101, RK 8608 x Laha 101, RK 8604 x Mathura Rai, RK 9002 x Mathura Rai and RK 918506 x Vaibhav were common at both the environments as well as in pooled analysis. In F_2 generation 10 at E_1, 8 at E_2 and 15 in pooled analysis were found the best specific combinations as they revealed significant and desirable sca

effects. On the basis of merit, 8 superior crosses at each environment and pooled over these environments were sorted out as RK 8702 x Mathura Rai, RK 9 x Laha 101, RK 911296 x Mathura Rai, RK 8608 x Vaibhav, RK 8601 x Vaibhav, RK 8903 x Laha 101, RK 8601 x Laha 101 and RK 8803 x Vaibhav in E_1; RK 9 x Laha 101, RK 8803 x Vaibhav, RK 8702 x Mathura Rai, RK 8608 x Vaibhav, RK 911296 x Mathura Rai, RK 8903 x Laha 101, RK 8601 x Laha 101 and RK 8601 x Vaibhav in E_2; RK 9 x Laha 101, RK 8702 x Mathura Rai, RK 8608 x Vaibhav, RK 8803 x Vaibhav, RK 911296 x Mathura Rai, RK 8903 x Laha 101, RK 8601 x Vaibhav and RK 8601 x Laha 101 on pooled basis. In these cross combinations all were common in E_1, E_2 and pooled analysis. In these combinations none was common in F_1, F_2 and in pooled analysis.

The number of crosses exhibiting desirable and significant specific combiners for days to reproductive phase in F_1 hybrid combinations were 15 at E_1, 21 at E_2 and 14 in pooled basis. Out of these, 10 cross combinations namely, RK 8701 x Vaibhav, RK 9002 x Vaibhav, RK 9001 x Mathura Rai, RK 8903 x Laha 101, RK 8605 x Laha 101, RK 918506 x Laha 101, RK 911296 x Laha 101, RK 8605 x Mathura Rai, KRV 47 x Vaibhav and RK 8902 x Mathura Rai in normal sown situation (E_1); RK 8701 x Vaibhav, RK 9001 x Mathura Rai, RK 8801 x Laha 101, RK 8605 x Laha 101, RK 918506 x Laha 101, RK 9002 x Vaibhav, RK 911296 x Laha 101, RK 8902 x Laha 101, KRV 47 x Vaibhav and RK 8605 x Mathura Rai in late sown situation (E_2); RK 8701 x Vaibhav, RK 9001 x Mathura Rai, RK 9002 x Vaibhav, RK 8605 x Laha 101, RK 918506 x Laha 101, RK 911296 x Laha 101, RK 8605 x Mathura Rai, KRV 47 x Vaibhav, RK 8903 x Laha 101 and RK 8902 x Mathura Rai in pooled analysis. Among these 7 combinations namely, RK 8701 x Vaibhav, RK 9002 x Vaibhav, RK 9001 x Mathura Rai, RK 8605 x Laha 101, RK 911296 x Laha 101, RK 8605 x Mathura Rai and KRV 47 x Vaibhav were common to both the environments as well as in pooled analysis. In F_2 progenies, 9 crosses at E_1, 20 crosses at E_2 and 13 crosses in pooled analysis has sown significant and desirable sca effects. Out of these, 9 crosses on merit basis, at each sowing dates (environments) were RK 8602 x Laha 101, RK 8608 x Vaibhav, RK 918506 x Mathura Rai, RK 8702 x Mathura Rai, RK 8601 x Laha 101, RK 9001 x Vaibhav, RK 8902 x Laha 101, RK 8902 x Mathura Rai and RK 9002 x Vaibhav in E_1; RK 8602 x Laha 101, RK 8608 x Laha 101, RK 8702 x Mathura Rai, RK 8601 x Laha 101, RK 8902 x Laha 101, RK 9002 x Vaibhav, RK 9001x Vaibhav, RK 9 x Mathura Rai and RK 8702 x Vaibhav in E_2 and RK 8602 x Laha 101, RK 8608 x Vaibhav, RK 8702 x Mathura Rai, RK 8902 x Mathura Rai, RK 8601 x Laha 101, RK 8902 x Laha 101, RK 9001 x Vaibhav, RK 9002 x Vaibhav and RK 9002 x Laha 101 on pooled basis. In these 9 cross combinations RK 8602 x Laha 101, RK 8702 x Mathura Rai, RK 8601 x Laha 101 and RK 9001 x Vaibhav were representing

common in both the environments and in pooled analysis. More over if 10 cross combinations were considered at a time at both the environments in both the generations and in pooled analysis, one combination was found common, RK 9002 x Vaibhav, representing greater amount of stability over the environments and generations and was worthy for its exploitation in further breeding purposes.

In case of number of primary branches, 23 cross combinations at E_1, 20 cross combinations in E_2 and 26 crosses on pooled basis revealed significant and desirable sca effects in F_1 generation. Among these, 10 crosses, in order of ranking, RK 918506 x Mathura Rai, RK 8608 x Laha 101, RK 14 x Laha 101, RK 8901 x Vaibhav, RK 8801 x Vaihbav, RK 8902 x Vaibhav, RK 8903 x Mathura Rai, RK 8602 x Mathura Rai, KRV 47 x Vaibhav and RK 8605 x Vaibhav in normal sown situation (E_1); RK 918506 x Mathura Rai, RK 14 x Mathura Rai, RK 8608 x Laha 101, RK 8801 x Vaibhav, RK 8903 x Mathura Rai, RK 8902 x Vaibhav, RK 8602 x Mathura Rai, KRV 47 x Vaibhav, RK 8602 x Laha 101 and RK 8802 x Laha 101 in Late sown situation (E_2) and RK 918506 x Mathura Rai, RK 14 x Mathura Rai, RK 8701 x Laha 101, RK 8901 x Vaibhav, RK 8801 x Vaibhav, RK 8902 x Vaibhav, RK 8903 x Mathura, RK 8602 x Mathura Rai, KRV 47 x Vaibhav and RK 8702 x Laha 101 in pooled analysis five cross combinations namely, RK 918506 x Mathura Rai, RK 8801 x Vaibhav, RK 8903 x Mathura Rai, RK 8602 x Mathura Rai and KRV 47 x Vaibhav, were common in both the environments (E_1 and E_2) and on pooled basis in first filial generation. In F_2 population 16 in E_1, 12 in E_2 and 22 on pooled basis showed significant and desirable sca effects. In order of merits, 10 cross combination were RK 8801 x Mathura Rai, RK 9002 x Vaibhav, RK 8701 x Mathura Rai, RK 8604 x Mathura Rai, RK9 x Vaibhav, RK 8901 x Laha 101, RK 8605 x Vaibhav, RK 918506 x Vaibhav, RK 14 x Mathura Rai and RK 8902 x Laha 101 in E_1, RK 8801 x Mathura Rai, RK 8701 x Mathura Rai, RK 8604 x Mathura Rai, RK 8901 x Laha 101, RK 8605 x Vaibhav, RK 14 x Mathura Rai, RK 8902 x Laha 101, RK 8801 x Mathura Rai, RK 8903 x Vaibhav, and RK 9001 x Laha 101 in E_2 and RK 8801 x Mathura Rai, RK 9002 x Vaibhav, RK 8701 x Mathura Rai, RK 8604 x Mathura Rai, RK 8702 x Vaibhav, RK 8701 x Mathura Rai, RK 8901 x Laha 101, RK 9 x Vaibhav, RK 8605 x Vaibhav, RK 14 x Mathura Rai and RK 8902 x Laha 101 In pooled basis Among these, 7 cross combinations RK8801 x Mathura Rai, RK 8701 x Mathura Rai, RK 8604 x Mathura Rai, RK 8901x Laha 101, RK 8605 x Vaibhav x Vaibhav, RK 14 x Mathura Rai and RK 8902 x Laha 101 were common in both the environments as well as in second filial generation. In these crosses, RK8801 x Vaibahv was representing common in both the environments, generations and in pooled analysis showing high degree of stability for number of primary branches in this cross combination and it was desirable in future crossing programme as well as isolating desirable genotypes from advanced generations.

In F_1 generation, significant and desirable sca effects for number of secondary branches were observed in 14 cross combinations each at E_1 and E_2 and 18 cross combinations on pooled basis. In these, 10 F_1s, in order of merit, had been RK 8802 x Mathura Rai, RK 8803 x Mathura Rai, RK 8903 x Vaibhav, RK 8604 x Vaibhav, RK 8602 x Laha 101, RK 8801 x Mathura Rai, RK 8601 x Vaibhav, RK8608 x Mathura Rai, RK 14 x Laha 101 and RK 8701 x Vaibhav in E_1; RK 8802 x Mathura Rai, RK 8803 x Mathura Rai, RK 8903 x Vaibhav, RK 8602 x Laha 101, RK8604 x Laha 101, RK 8801 x Mathura Rai, RK 8601 x Mathura Rai, RK8601 x Vaibhav, RK 9001 x Laha 101, RK8608 x Mathura Rai, and RK 14 x Laha 101 in E_2 and RK 8802 x Mathura Rai, RK 8803 x Mathura Rai, RK 8903 x Vaibhav, RK 8602 x Laha 101, RK 8604 x Vaibhav, RK 8801 x Mathura Rai, RK 8608 x Mathura Rai, RK 14 x Vaibhav, RK 9001 x Laha and RK8608 Laha 101 in pooled basis. Among these 6 cross combinations (RK 8802 x Mathura Rai, RK 880 x Mathura Rai, RK 8903 x Vaibhav, RK 8602 x Laha 101, RK 8801 x Mathura Rai, and RK8608 x Mathura Rai) were common in respect of environments (E_1 and E_2) and pooled over environments in F_1 generation. In F_2 progenies, 8 crosses each in E_1 as well as in E_2 and 12 crosses on pooled basis revealed significant and desirable sca effects. Out of these, 8 combinations, in order of merit, at each environments were RK 8605 x Laha 101, RK 8608 x Laha 101 RK911296 x Vaibhav, RK 8601 x Laha 101, RK9 x Mathura Rai, RK 8604 x Vaibhav, RK8802 x Laha 101 and RK 8702 x Vaibhav in E_1; RK 8608 x Laha 101, RK 8605 x Laha 101, RK 8604 x Vaibhav, RK 911296 x Vaibhav, RK 8601 x Laha 19, RK 9 x Mathura Rai, RK 8901 x Laha 101 and RK 8802 x Laha 101 in E_2 and RK 8608 x Laha 101, RK 8605 x Laha 101, RK 911296 x Vaibhav, RK 8601 x Laha 101, RK 8604 x Vaibhav, RK9 x Mathura Rai, RK 8901 x Mathura Rai and RK 8802 x Laha 101 on pooled basis. Cross Combinations namely, RK 8605 x Laha 101, RK 8608 x Laha 101, RK 911296 x Vaibhav, RK 8601 x Laha 101 RK 9 x Mathura Rai RK 8604 x Vaibhav and RK 8802 x Laha 101 were Common in respect of environments and pooled over environments in F_2 generation.

In case of height of plant, 16 cross at E_1, 20 crosses at E_2 and 24 on pooled basis were found desirable and significant combinations in F_1, ten crosses, in order of ranking, were RK918506 x Laha101, RK 8803 x Vaibhav, RK 8602 x Vaibhav, RK 8604 x Vaibhav, RK 8601 x Laha 101, RK 8902 x Laha, RK 14 x Laha 101, RK 9 x Vaibhav, RK 8608 x Mathura Rai and RK 9001 x Laha 101 under normal sown condition (E_1); RK 8803 x Vaibhav, RK 9 x Vaibhav, RK 8604 x Vaibhav, RK 918506 x Laha 101, RK 8602 x Vaibhav, RK 8702 x Laha 101, RK 8701 x Vaibhav, RK 14 x Laha 101, RK 8604 x Laha 101 and RK 8902 x Mathura Rai under date sown situation (E_2) and RK 8803 x Vaibhav, RK 918506 x Laha 101, RK 8604 x Vaibhav, RK 8601 x Vaibhav, RK 9 x Vaibhav,

RK 8601 Laha 101, RK 8702 x Laha 101, RK 14 x Laha 101, RK 8903 x Vaibhav and RK 8902 x Laha 101 on pooled basis four combinations namely RK 918506 x Laha 101, RK 8604 x Vaibhav, RK 14 x Laha 101 and RK 9 x Vaibhav were common specific combinations at both the date of sowings and pooled over these date for sowings. In F_2 population, 13 cases in E_1, 29 cases in E_2 and 23 cases on pooled basis were sorted out as desirable specific combiners as these combinations showed significant sca effects. Out of these combinations 10 crosses in each environment and pooled over the environments, in order of merit, were RK 9002 x Vaibhav, RK 8601 x Vaibhav, KRV 47 x Mathura Rai, RK 918506 x Laha 101, RK 911296 x Mathura Rai, RK 8901 x Laha 101, RK 8602 x Laha 101, RK 8802 x Laha 101, RK 8702 x Vaibhav and RK 8702 x Laha 101 in E_1; RK 9002 x Vaibhav, RK 8601 x Vaibhav, RK 8608 x Vaibhav, RK 8902 x Laha 101, RK 14 x Vaibhav, RK 9 x Mathura Rai, RK 8802 x Vaibhav, RK 8801 x Vaibhav, RK 8803 x Laha 101 and RK 8601 x Mathura Rai in E_2 and RK 9002 x Vaibhav, RK 8601 x Vaibhav, RK918506 x Laha 101, RK 8608 x Vaibhav, RK 8802 x Vaibhav, RK 8801 x Vaibhav, RK 14 Vaibhav, RK 8601 x Mathura Rai, RK 8702 x Mathura Rai and RK 8605 x Mathura Rai on pooled basis. Among these combinations, RK 9002 x Vaibhav and RK 8601 x Vaibhav were common specific combiners in both the environments and pooled over these environments.

In respect of length of main fruiting branch, the crosses which exhibited significant and desirable sca effects were 18 in number at E_1, 10 at E_2 and 20 pooled over analysis in first filial generation. Out of these, 10 crosses, in order of ranking, were RK 911296 x Vaibhav, RK 9002 x Laha 101, RK 8901 x Mathura Rai, KRV 47 x Laha 101, RK 14 x Laha 101, RK 8608 x Laha 101, RK 8701 x Mathura Rai RK 8902 x Vaibhav and RK 8803 x Vaibhav K 8702 x Vaibhav in E_1; RK 911296 x Vaibhav, RK 8702 x Vaibhav, RK 8608 x Laha 101, RK 9002 x Laha 101, RK 8901 x Mathura Rai, RK 14 x Laha 101, KRV 47 x Laha 101, RK 8605 x Laha 101, RK 8701 x Mathura Rai and RK 911296 x Mathura Rai in E_2 and RK 911296 x Vaibhav, RK 8902 x Laha 101, RK 9002 x Laha 101, RK 8901 x Mathura Rai, RK 8702 x Vaibhav, RK 8608 x Laha 101, KRV 47 x Laha 101, RK 14 x Laha 101, RK 8701 x Mathura Rai and RK8902 x Vaibhav on pooled basis. Among these crosses all were common except RK 8902 x Vaibhav and RK 8803 x Vaibhav at both the environments and in pooled basis as well. In F_2 progenies, 21 in E_1, 18 in E_2 and 22 on pooled basis were found to be the best specific combiners on the basis of significants and desirable sca effects. Out of these 10 crosses, in order of merit, RK 8605 x Vaibhav, RK 8601 x Mathura Rai, RK 8901 x Vaibhav, KRV 47 x Mathura Rai, RK 9001 x Vaibhav, RK 9 x Laha 101, RK 8608 x Laha 101, RK 8801 x Laha 101, RK 8602 x Laha 101 and RK9 x Vaibhav in E_1; RK 8608 x Mathura Rai, RK8605 x Vaibhav, RK8601 x Laha, RK

8601 x Mathura Rai, RK 8901 x Vaibhav, RK9 x Laha 101, RK 9001 x Vaibhav, RK 8803 x Laha 101, RK 8901 x Laha 101 and RK 9 x Vaibhav in E_2 and RK 8605 x Vaibhav, RK 8601 x Mathura Rai, RK8901 x Vaibhav, RK 8902 x Vaibhav, RK 9001 x Vaibhav, RK 8802 x Laha 101, RK9 x Laha 101, KRV 47 x Mathura Rai, RK 8608 x Mathura Rai and RK 8602 x Laha 101 on pooled analysis. Among These progenies, five combination namely, RK 8605 x Vaibhav, RK 8601 x Mathura Rai, RK 8901 x Vaibhav, RK 9001 x Vaibhav and RK9x Laha 101 were common at both the environments and pooled analysis too.

In case of number of siliquae on main fruiting branch, 20 cases at E_1, 22 cases at E_2 and 23 cases on pooled basis revealed significant and desirable sca effects in F_1 generation out of these 10 crosses combinations, in order of merit were RK 14x Vaibhav, RK 918506 x Laha 101, RK 8802 x Mathura Rai, RK 8902 x Laha 101, RK 8605 x Laha 101, RK 8903 x Vaibhav, RK 9001 x Mathura Rai, RK 8801 x Vaibhav, RK 8602 x Vaibhav and RK 8701 x Laha 101 in E_1; RK 14 x Vaibhav, RK 918506 x Laha 101, RK8802 x Mathura Rai, RK 8902 x Laha 101, RK 8605 x Laha 101, RK 8903 x Vaibhav, RK 9001 x Mathura Rai, RK 8801 x Vaibhav, RK 8701 x Laha 101and RK 8602 x Vaibhav in E_2 and RK 14 x Vaibhav, RK 918506 x Laha 101, RK 8802 x Mathura Rai, RK 8902 x Laha 101, RK 8605 x Laha 101, RK 8903 x Vaibhav, RK 9001 x Mathura Rai , RK 8801 x Vaibhav, RK 8602 x Vaibhav and RK 8701 x Laha 101 on pooled basis and all were common in both the environment and pooled analysis. In F_2 population, 11 in E_1 .24 in E_2 and 17 on pooled basis were sorted out as desirable specific combiners as these combination revealed significant sca effects. Out of these, 10 cross combinations at each location and in pooled analysis were RK 8901 x Laha 101, RK 9002 x Laha 101, RK8601 x Mathura Rai, RK 8702 x Vaibhav, RK911296 x Vaibhav, RK 8803 x Mathura Rai, RK9 x Vaibhav, RK 8803 x Laha 101, KRV47 x Mathura Rai and RK 9001 x Mathura Rai in E_1; RK 9002 x Laha 101, RK 8601 x Mathura Rai, RK 8902x Laha 101, RK 8702 x Vaibhav, RK 911296 x Vaibhav, RK9 x Vaibhav, RK 8803 x Mathura Rai RK 9 xVaibhav, RK 8903 x Laha 101 KRV 47 x Mathura Rai and, RK 8702 x Laha 101, and RK 8801 x Laha 101 in RK 8901 x Laha 101, RK 9002 x Laha 101, RK 8906 x Mathura Rai, RK 8702 x Vaibhav, RK 911296 x Vaibhav, RK 8903 x Laha 101, RK 9 x Vaibhav, RK 8803 x Mathura Rai, KRV 47 x Mathura Rai and RK9001 x Mathura Rai on pooled basis. Out of these combinations, RK 9002 x Laha 101, RK 8601 x Mathura Rai, RK 8702 x Vaibhav, RK 911296 x Vaibhav, RK 9x Vaibhav and RK8903 x Laha 101 were common in both the environments and pooled over environments.

In F_1 generation, significants and desirable sca effects for days to maturity were observed in 17 cross combination at E_1, 12 at E_2 and 16 on pooled basis. In

these, 10 crosses in order of ranking, RK 9002x Laha 101, RK 8902 x Laha 101, RK 8802 x Vaibhav, RK 8702 x Vaibhav, RK 8903 x Mathura Rai, RK 14x Laha 101, 8801 x Vaibhav, KRV 47 x Laha 101, RK 8701 x Mathura Rai and RK 8901 x Mathura Rai in E_1; RK 9002 x Laha 101, RK 8802 x Laha 101, RK 8802 x Vaibhav, RK 8505 x Mathura Rai, RK 8802 x Mathura Rai, RK 8702 x Vaibhav, RK 8903 x Mathura Rai, KRV 47 x Laha 101, RK14 X Laha 101 and RK 8901 x Mathura Rai in E_2 and RK 9002 x Laha 101, RK 8802 x Vaibhav RK 8702 x Vaibhav, RK 8903 x Mathura Rai, RK 14 x Laha 101, KRV47 x Laha 101, RK 8801 x Vaibhav, RK 8901 x Mathura Rai, RK 9002 x Mathura Rai and RK 8902 x Laha 101 on pooled basis. Among these, 7 combinations namely, RK 9002 x Laha 101, RK 8802 x Vaibhav, RK 8702 x Vaibhav, RK 8903 x Mathura Rai, RK 14 x Laha 101and KRV 47 x Laha 101 were common in respect of environments and pooled over environments. In F_2 progenies, 24 crosses in E_1, 17 crosses in E_2 and 22 in pooled analysis revealed significant and desirable sca effects. Out of these, 10 combinations, in order of merit, in each environment and pooled over environment were RK 911296 x Mathura Rai, RK 8903 x Laha 101, RK 9 x Laha 101, RK 8605 x Laha 101, RK 14 x Mathura Rai, RK 8902 x Vaibhav, RK 8903 x Mathura Rai, RK 9001 x Laha 101, RK 8605 x Mathura Rai and RK 8901 x Mathura Rai in E_1; RK 9 x Laha 101, RK 8903 x Laha 101, RK 918506 x Mathura Rai, RK 14 x Laha 101, RK 14 x Mathura Rai, RK 9001 x Laha 101, RK 8608 x Laha 101, RK 8605 x Mathura Rai, RK 8901 x Mathura Rai and RK 9 x Vaibhav in E_2 and RK 9 x Laha 101, RK 911296 x Mathura Rai, RK 14 x Mathura Rai, RK 9001 x Laha 101, RK 8701 x Vaibhav, RK 8605 x Mathura Rai, RK 8605 x Laha 101, RK 8901 x Mathura Rai and RK 8902 x Vaibhav on pooled basis. Among these, 6 combinations namely, RK 9 x Laha 101, RK 8903 x Laha 101,RK 14 x Mathura Rai, RK 9001 x Laha 101, RK 8605 x Mathura Rai and RK 8901 x Mathura Rai were common in respect of environments and pooled over environments.

In case of relative water content, the crosses, which revealed significant and desirable sca effects were 23 at E_1, 19 at E_2 and 23 on pooled over these environments in first filial generation. Among these, 10 combinations, in order of merit, were RK 8602 x Laha 101, RK 9001 x Mathura Rai, RK 8604 x Laha 101, RK 8801 x Vaibhav, RK 8903 x Vaibhav, RK 9002 x Mathura Rai, RK 8803 x Laha 101, RK 8901 x Mathura Rai RK 8601 x Laha 101, and RK 8601 x Mathura Rai in E_1, RK 8602 x Laha 101, RK 9001 x Mathura Rai, RK 8604 x Laha 101, RK 8801 x Vaibhav, RK 8903 x Vaibhav, RK 9002 x Mathura Rai, RK 8803 x Laha 101, RK 8601 x Laha 101, RK 8901 x Mathura Rai and RK 8601 x Mathura Rai in E_2 and RK 8602 x Laha 101, RK 9001 x Mathura Rai, RK 8604 x Laha 101, RK 8801 x Vaibhav, RK 8903 x Vaibhav, RK 9002 x Mathura Rai, RK 8803 x Laha 101, RK 8601 x Laha 101, RK 8901 x Mathura Rai and RK 8601 x

Mathura Rai on pooled basis and all were common in respect of environments and pooled over environments. In F_2 population, 17 each in E_1 as well as in E2 and 21 on pooled basis revealed significant and desirable sca effects. Out of these 10 crosses at each environment, in order of merit were RK 8701 x Vaibhav, RK 8701 x Laha 101, RK 8802 x Laha 101, RK 8602 x Mathura Rai, RK 8608 x Vaibhav, RK 8801 x Mathura Rai, RK 8903 x Laha 101, RK 8901 x Vaibhav, RK 8605 x Vaibhav, and RK 8803 x Laha 101 in E_1; RK 8701 x Vaibhav, RK 8702 x Laha 101, RK 8802 x Laha 101, RK 8602 x Mathura Rai, RK 8608 x Vaibhav, RK 8801 x Mathura Rai, RK 8903 x Laha 101, RK 8901 x Vaibhav, RK 8605 x Vaibhav and RK 8902 x Vaibhav in E_2; and RK 8701 x Vaibhav, RK 8702 x Laha 101, RK 8801 x Laha 101, RK 8602 x Mathura Rai, RK 8608 x Vaibhav, RK 8801 x Mathura Rai, RK 8903 x Laha 101, RK 8901 x Vaibhav, RK 8605 x Vaibhav and RK 8803 x Vaibhav on pooled basis. Among these, 8 cross combinations were common in both the environments and in pooled analysis. In these cross combinations. RK 8803 x Laha 101 was the common in both the environments as well as in both generations and in pooled analysis indicating high degree of stability for relative water content in this cross.

The number of crosses which indicating significant and desirable sca effects for leaf water potential in F_1 generation were 19 at normal sown condition (E_1) , 15 in late sown situation and 21 on pooled basis. Ten combinations on merit were RK 911296 x Laha 101, KRV 47 x Mathura Rai, RK 9002 x Mathura Rai, RK 8902 x Vaibhav, RK 9001 x Vaibhav, RK 8802 x Vaibhav, RK 8702 x Vaibhav RK 9 x Laha 101, RK 918506 x Mathura Rai and RK 8903 x Vaibhav in E_1; RK 8802 x Vaibhav, RK 911296 x Laha 101, KRV 47 x Mathura Rai, RK 9002 x Mathura Rai, RK 8902 x Vaibhav, RK 9001x Vaibhav, RK 8903 x Mathura Rai, RK 8702 x Vaibhav, RK 918506 x Mathura Rai and RK 9 x Laha 101 in E_2 and RK 911296 x Laha 101, KRV 47 x Mathura Rai, RK 9002 x Mathura Rai, RK 8902 x Vaibhav, RK 8802 x Vaibhav, RK 9001 x Vaibhav, RK 8702 x Vaibhav, RK 9 x Laha 101, RK 918506 x Mathura Rai and RK 8901 x Laha 101 on pooled basis and all were common in both the environments except RK 8903 x Vaibhav. In F_2 generation, 18 combinations in E_1, 13 combinations in E_2 and 19 combinations on pooled basis had shown significant and desirable sca effects. Among these, 10 crosses in order of merit were RK 9001 x Vaibhav, RK 8902 x Vaibhav, RK 918506 x Vaibhav, RK 8602 x Mathura Rai, RK 9001 x Laha 101, RK 14 x Mathura Rai, RK 8901 x Mathura Rai, RK 8803 x Laha 101, RK 8702 x Laha 101and 8701 x Laha 101 in E_1; RK 9002 x Vaibhav, RK 8902 x Vaibhav, KRV 47 x Mathura Rai, RK 918506 x Vaibhav, RK 8602 x Mathura Rai, RK 14 x Mathura Rai, RK 8901 x Mathura Rai, RK 9001 x Laha 101, RK 8605 x Laha 101 and RK 8803 x Laha 101 in E_2 ; RK 9002 x Vaibhav, RK 8902 x Laha 101, RK 918506 x Vaibhav, RK 9001 x Laha 101, RK 8602 x Mathura

Rai, RK 14 x Mathura Rai, RK 8901 x Mathura Rai, KRV 47 x Mathura Rai, RK 8702 x Laha 101 and RK 8701 x Laha 101 on pooled basis. Among these, four cross combinations were common in both the environments.

In case of yield per plant, 27 crosses each in E_1, E_2 and in pooled analysis exhibited significant and desirable sca effects in first filial generation. Out of these, 10 crosses, in order of merit, were RK 8802 x Laha 101, RK 8701 x Vaibhav, RK 8601 x Mathura Rai, RK 8803 x Vaibhav, RK 9002 x Laha 101, RK 918506 x Mathura Rai, RK 8901 x Mathura Rai, RK 8608 x Laha 101, RK 8902 x Mathura Rai and RK 8903 x Laha 101 in E_1; RK8802 x Laha 101, RK 8701 x Vaibhav, RK 8601 x Mathura Rai, RK 9002 x Laha 101, RK 8803 x Vaibhav, RK 918506 x Mathura Rai, RK 8901 x Mathura Rai, RK 8608 x Laha 101, RK 8902 x Mathura Rai and RK 8903 x Laha 101 in E_2 and RK 8802 x Laha 101, RK 8701 x Vaibhav, RK 8601 x Mathura Rai, RK 9002 x Laha 101, RK 8803 x Vaibhav, RK 918506 x Mathura Rai, RK 8901 x Mathura Rai, RK 8608 x Laha 101, RK 8902 x Mathura Rai and RK 8903 x Laha 101 on pooled basis and all were common in both the environment, indicating stability from normal to late planting in these crosses. In F_2 progenies, 20 crosses in E_1, 22 crosses in E_2 and 24 crosses in pooled analysis revealed significant and desirable sca effects. Out of these, 10 combination, in order of ranking were RK 8601 x Vaibhav, RK 8801 x Mathura Rai, RK 8702 x Mathura Rai, KRV 47 x Mathura Rai, RK 8902 x Mathura Rai, RK 9 x Laha 101, RK 8803 x Mathura Rai, RK 8701 x Laha 101, RK 8605 x Vaibhav and RK 8604 x Vaibhav in E_1; RK 8601 x Vaibhav, RK 8801 x Mathura Rai, RK 8901 x Laha 101, RK 8702 x Mathura Rai, KRV 47 x Mathura Rai, RK 8902 x Mathura Rai, RK 9 x Laha 101, RK 8803 x Mathura Rai, RK 8605 x Vaibhav and RK 8804 x Vaibhav in E_2 and RK 8601 x Vaibhav, RK 8801 x Mathura Rai, RK 8702 x Mathura Rai, KRV 47 x Mathura Rai, RK 8902 x Mathura Rai, RK 9 x Laha 101, RK 8803 x Mathura Rai, RK 8605 x Vaibhav, RK 8701 x Laha 101 and RK 8604 x Vaibhav on pooled basis. Among these, all were common if 11 significant and desirable cross combinations were taken into consideration in both the environment. In these cross combinations, RK 8902 x Mathura Rai was common in both the environments as well as both the generations and pooled analysis indicating high degree of stability for yield per plant over the environments and over the generations.

In F_1 generation, significant and desirables sca effect for oil content were observed in 16 combinations at normal sowing condition, 18 combinations at late sown situation and 19 combinations on pooled basis. In these, 10 crosses, in order of ranking, were KRV 47 x Mathura Rai, RK 14 x Vaibhav, RK 8601 x Mathura Rai, RK 8604 x Vaibhav, RK 8701 x Mathura Rai, RK 8605 x Laha 101, RK 8608 x Vaibhav, RK 8801 x Vaibhav, RK 8602 x Vaibhav and RK 8702 x

Vaibhav in E_1; KRV 47 x Mathura Rai, RK 14 x Vaibhav, RK 8702 x Vaibhav, RK 8601 x Mathura Rai, RK 8604 x Vaibhav, RK 8701 x Mathura Rai, RK 8605 x Laha 101, RK 8801 x Vaibhav, RK 8608 x Vaibhav and RK 8602 x Vaibhav in E_2 and KRV 47 x Mathura Rai, RK 14 x Vaibhav, RK 8601 x Mathura Rai, RK 8702 x Vaibhav, RK 8604 x Vaibhav, RK 8701 x Mathura Rai, RK 8605 x Laha 101, RK 8801 x Vaibhav, RK 8608 x Vaibhav and RK 8602 x Vaibhav on pooled basis and all were common in both the environments. In F_2 progenies, 25 combinations at E_1, 24 combination at E_2 and 25 combinations on pooled basis had given significant and desirable specific combiners. Among these, 10 combination in order of ranking were RK 8601 x Laha 101, RK 911296 x Vaibhav, RK 8605 x Vaibhav, RK 9001 x Mathura Rai, RK 8801 x Laha 101, RK 8701 x Laha 101, RK 8602 x Mathura Rai, RK 9002 x Mathura Rai, RK 8601 x Vaibhav and RK 911296 x Mathura Rai, in E_1; RK 911296 x Vaibhav, RK 8605 x Vaibhav, RK 8801 x Laha 101, RK 9001 x Mathura Rai,, RK 8701x Laha 101, RK 8602 x Mathura Rai, RK 8602 x Mathura Rai, RK 9002 x Mathura Rai, RK 8601 Laha 101, RK 918506 x Mathura Rai and RK 8901 x Vaibhav in E_2 and RK 911296 x Vaibhav, RK 8605 x Vaibhav, RK 9001 x Mathura Rai, RK 8801 x Laha 101, RK 8701 x Laha 101, RK 8602 x Mathura Rai, RK 9002 x Mathura Rai, RK 8601 x Laha 101, RK 918506 x Mathura Rai and RK 8901 x Vaibhav over pooled basis. Among these 8 combination namely RK 8601 x Laha 101, RK 911296 x Vaibhav, RK 8605 x Vaibhav, RK 9001 x Mathura Rai, RK 8801 x Laha 101, RK 8701 x Mathura Rai, and RK 9002 x Mathura Rai were common in both normal and late planting situation indicating stability in performance for oil content from timely sown to late sown.

The number of crosses which indicated significant and desirable sca effects for erucic acid in F_1 generation were RK 8901 x Mathura Rai at normal sown condition (E_1), two in late sown situation namely, RK 911296 x Laha 101 and RK 9 x Laha 101. None was found desirable specific combiner in E_2 for F_1 and F_2 as well as on pooled analysis in these two generations.

HETEROSIS AND INBREEDINGS DEPRESSION :

Heterosis:

Heterosis was calculated in percent increase or decrease over best cultivar in F_1's for all the 13 characters. In the present study, economic parent (cultivar) was considered the widely adapted cultivar *Mathura Rai* which was a selection and was widely cultivated variety in Indian mustard growing tracts of the State. The present study was also conducted under both normal and late plantings with irrigated and adequate fertility conditions, hence, the choice of Mathura Rai as economic parent was appropriate. Estimates of such economic heterosis for 13

characters individually for each environment and on pooled basis are presented in Table 8a.

Negative and significant values of economic heterosis were considered desirable for days to flowering, height of plant, days to maturity and erucic acid. On the other hand, positive and significant values were considered desirable for other attributes namely days to reproductive phase, number of primary branches, number of secondary branches, length of main fruiting branch, number of siliquae on main fruiting branch, relative water content, leaf water potential, yield per plant and oil content.

The magnitude of heterosis over economic parent for days to flowering ranged from – 18.50 to 9.22 per cent in E_1; - 14.97 to 21.47 in E_2 and – 16.72 to 15. 39 per cent on pooled basis exhibiting significant negative heterosis for 13, 22 and 16 hybrid combinations in E_1, E_2 and on pooled basis, respectively. Ten hybrid combinations, is order of merit, were RK 14x Vaibhav, RK 8901 x Mathura Rai, RK 8605 x Laha 101, RK 9002 x Mathura Rai, KRV 47 x Vaibhav, RK 14 x Laha 101, RK 8608 x Mathura Rai, RK 8801 x Mathura Rai, RK 8604 x Mathura Rai, and RK 8702 x Mathura Rai, in E_1, RK 8901 x Mathura Rai, RK 8605 x Laha 101, RK 8702 x Mathura Rai, RK 8604 x Mathura Rai, RK 9002 x Mathura Rai, RK 8605 x Mathura Rai, RK 8608 x Mathura Rai, RK 8701 x Mathura Rai, RK 8801 x Mathura Rai, and RK 8902 x Mathura Rai, in E_2, RK 8901 x Mathura Rai, RK 8605 x Laha 101, RK 9002 x Mathura Rai, RK 8604 x Mathura Rai, RK 8702 x Mathura Rai, RK 8801 x Mathura Rai, RK 8608 x Mathura Rai, RK 8605 x Mathura Rai, RK 8602 x Laha 101, RK 911296 x Mathura Rai in pooled analysis. The common hybrids in both the environments were RK 8901 x Mathura Rai, RK 9002 x Mathura Rai, RK 8608 x Mathura Rai, RK 8801 x Mathura Rai, RK 8604 x Mathura Rai, and RK 8702 x Mathura Rai,.

The range of economic heterosis with respect to days to reproductive phase was -4.61 to 12.29 per cent in E_1; 13.09 to 30.10 per cent in E_2; 4.47 to 20.55 per cent on pooled basis revealing 15, 60 and 18 significant economic hybrids, respectively. Among these, 10 hybrids in order of ranking, were RK 8602 x Vaibhav, RK 918506 x Laha 101, RK 9001 x Mathura Rai, RK 8901 x Vaibhav, RK 9001 x Vaibhav, RK 9002 x Vaibhav, RK 8605 x Laha 101, RK 8903 x Laha 101, RK 8601 x Vaibhav and RK 8701 x Laha 101 in E_1; RK 8801 x Laha 101, RK 8902 x Laha 101, RK 9001 x Mathura Rai, RK 918506 x Laha 101, RK 911296 x Mathura Rai, RK 8605 x Laha 101, RK 8901 x Vaibhav, RK 918506 x Mathura Rai, RK 8803 x Laha 101, and RK 9001 x Vaibhav in E_2 ; RK 9001 x Mathura Rai, RK 918506 x Laha 101, RK 8901 x Vaibhav, RK 8605 x Laha 101, RK 9001 x Vaibhav, RK 9002 x Vaibhav, RK 8903 x Laha 101, RK 8602 x Vaibhav, RK 911296 x Laha 101 and RK 8701 x Laha 101 in pooled analysis.

The common hybrids were RK 9001 x Mathura Rai, RK 8901 x Vaibhav, RK 9001 x Vaibhav and RK 8903 x Laha 101, when both the environments and pooled over these environments were considered together.

Range of economic heterosis with regard to number of primary branches was- 25.24 to 86.81 per cent at E_1, - 28.13 to 77.21 per cent at E_2 and – 26.18 to 82.10 per cent on pooled analysis. Significant and positive economic heterosis in 29 at E_1, 23 at E_2 and 20 in pooled analysis were regarded for this character. In order of sequence 10 significant and positive heterosis out of these cases were RK 8601 x Vaibhav, RK 918506 x Vaibhav, RK 8702 x Vaibhav, RK 8608 x Mathura Rai, RK 8608 x Laha 101, RK 8802 x Mathura Rai, RK 14 x Laha 101, KRV 47 x Laha 101, RK 8801 x Mathura Rai, and RK 9001 x Mathura Rai, in E_1; RK 8601 x Vaibhav, RK 8702 x Vaibhav, RK 8608 x Mathura Rai, RK 918506 x Vaibhav, RK 8608 x Laha 101, RK 8802 x Mathura Rai, RK 14 x Laha 101, RK 8801 x Mathura Rai, KRV 47 x Vaibhav and RK 9001 x Mathura Rai, in E_2, RK 8601 x Vaibhav, RK 918506 x Vaibhav, RK 8608 x Mathura Rai, RK 8608 x Laha 101, RK 8702 x Vaibhav, RK 8801 x Mathura Rai, RK 14x Laha 101, KRV 47 x Laha 101, KRV 47 x Vaibhav and RK 9001 x Mathura Rai, in pooled analysis. The common hybrids were RK 8601 x Vaibhav, RK 8702 x Vaibhav, RK 8608 x Mathura Rai, RK 918506 x Vaibhav, RK 8608 x Laha 101, RK 14 x Laha 101 and RK 9001 x Mathura Rai, when both the environments and pooled over these environments were considered together.

The magnitude of heterosis over economic parent for number of secondary branches ranged from – 10.06 to 150.00 per cent in E_1, - 15.34 to 142.40 per cent in E_2 and – 10.79 to 146.10 per cent on pooled basis exhibiting desirable and significant economic heterosis in 50 hybrids in E_1, 42 hybrids each in E_2 and pooled basis. Among these, 10 hybrids combinations, in order of merit, were RK 8801 x Laha 101, RK 8601 x Vaibhav, RK 8605 x Mathura Rai, RK 8608 x Laha 101, RK 14 x Laha 101, RK 8604 x Vaibhav, RK 9 x Mathura Rai, RK 8601 x Mathura Rai, RK 8602 x Mathura Rai and RK 9 x Laha 101 in E_1 ; RK 8801 x Laha 101, RK 8601 x Vaibhav, RK 8608 x Mathura Rai, RK 8608 x Laha 101, RK 14 x Laha 101, RK 8604 x Vaibhav, RK 9 x Mathura Rai, RK 8601 x Mathura Rai, RK 8602 x Mathura Rai, and RK 9 x Laha 101 in E_2 ; RK 8801 x Laha 101, RK 8601 x Vaibhav, RK 8608 x Mathura Rai, RK 8608 x Laha 101, RK 14 x Laha 101, RK 8604 x Vaibhav, RK 8601 x Mathura Rai, RK 8605 x Mathura Rai, RK 8602 x Mathura Rai, and RK 9 x Laha 101 in pooled analysis. All the economic hybrids were common in both the date of plantings and pooled over these sowing dates except RK 8605 x Mathura Rai and RK 9 x Mathura Rai,.

The range of economic heterosis with regards to height of plant ranged from – 13.79 to 33. 56 per cent at E_1, - 29.51 to 22. 88 per cent at E_2 and – 21.65

to 18.34 per cent in pooled analysis. Out of three significant and negative economic heterosis, hybrid RK 918506 x Laha 101, exhibited maximum desirable economic heterosis at E_1, E_2 and pooled. The other common economic hybrids were RK 8602 x Vaibhav and RK 14 x Laha 101.

In case of length of main fruiting branch, 39 at E_1, 29 at E_2 and 30 on pooled basis exhibited significant, positive and desirable economic heterosis. The range of variation of hybrid vigour over economic parent was – 13.4 to 34.40 per cent at E_1, -24.55 to 28.07 per cent at E_2 and – 13.29 to 28.82 per cent in pooled analysis. Hybrid combinations namely, RK 9002 x Laha 101, RK 8903 x Mathura Rai, RK 8802 x Laha 101, RK 8702 x Laha 101, RK 911296 x Mathura Rai, RK 8605 x Laha 101, RK 911296 x Vaibhav and KRV 47 x Mathura Rai, were common at both the environments and pooled over the environments.

Economic heterosis in case of number of siliquae on main fruiting branch varied from – 31.37 to 53.69 per cent consisting of 30 significant and positive hybrids at E_1 (normal sown situation) ; - 35.43 to 45.83 per cent with 15 hybrids at E_2 and – 33.40 to 51.05 per cent with 31 hybrids in pooled analysis. In 10 significant and positive hybrid vigour over economic parent were RK 9002 x Laha 101, RK 9001 x Vaibhav, RK 8608 x Laha 101, RK 14 x Laha 101, RK 9002 x Vaibhav, RK 8601 x Vaibhav, RK 918506 x Laha 101, RK 8903 x Vaibhav, RK 8702 x Vaibhav and RK 8803 x Vaibhav in E_1 ; RK 9 x Mathura Rai, RK 9002 x Laha 101, RK 9001 x Vaibhav, RK 8608 x Laha 101, RK 14 x Laha 101, RK 9002 x Vaibhav, RK 8601 x Vaibhav, RK 918506 x Laha 101, RK 9 x Vaibhav and RK 8903 x Vaibhav in E_2 ; RK 8702 x Vaibhav, RK 9002 x Laha 101, RK 9001 x Vaibhav, RK 8608 x Laha 101, RK 14 x Laha 101, RK 9002 x Vaibhav, RK 8601 x Vaibhav, RK 918506 x Laha 101, RK 8903 x Vaibhav and RK 8803 x Vaibhav on pooled analysis eight being common in both the planting dates and pooled over these date of sowing.

In case of day to maturity, the range of heterosis over economic parent varied from – 9.63 to 6.76 per cent with 5 significant and desirable hybrids at E_1, -6.64 to 8.85 per cent with 2 significant desirable hybrids at E_2 and –7.67 to 8.19 per cent with 4 significant and desirable hybrids in pooled analysis. Among these two hybrids namely, RK 8901 x Mathura Rai, and RK 8702 x Mathura Rai, were the common at both the environments and pooled over the environments.

The economic heterosis for relative water content, 13 hybrids at E_1, showing the range from –16.84 to 9.25 per cent, 17 hybrids at E_2 with the range from –24.78 to 14.33 per cent and 18 hybrids with the range from –16.84 to 9.25 per cent in pooled analysis showed vigour. Among these, the common hybrids

were RK 9001 x Laha 101, RK 9 x Mathura Rai, RK 14 x Vaibhav and RK 8605 x Vaibhav in both the environments and pooled over the environments.

Ten hybrids at E_1, 24 hybrids at E_2 and 19 hybrids on pooled over these environments (E_1 and E_2) surpassed the economic parent in desirable and significant direction for leaf water potential. The range of these hybrids vigour for this attribute varied from –60.43 to 29.28 per cent in E_1, -44.37 to 51.65 per cent in E_2 and –48.61 to 40.46 per cent in pooled analysis which indicated high heterosis with high genetic diversity for the character. Ten hybrids among these, in order of merit, were RK 8902 x Laha 101, RK 8901 x Laha 101, RK 918506 x Mathura Rai, RK 8702 x Mathura Rai, RK 9001 x Laha 101, RK 8903 x Laha 101, RK 8801 x Mathura Rai, RK 8802 x Mathura Rai, RK 8801 x Vaibhav and RK 911296 x Laha 101 in E_1; RK 8902 x Laha 101, RK 8901 x Laha 101, RK 918506 x Mathura Rai, RK 14 x Mathura Rai, RK 8903 x Laha 101, RK 8601 x Laha 101, RK 8802 x Mathura Rai, RK 911296 x Laha 101, RK 8901 x Mathura Rai, and RK 8601 x Mathura Rai, in E_2 ; RK 8902 x Laha 101, RK 8901 x Laha 101, RK 918506 x Mathura Rai, RK 8903 x Laha 101, RK 8802 x Mathura Rai, RK 8802 x Laha 101, RK 911296 x Laha 101, RK 8901 x Mathura Rai, RK 8601 x Mathura Rai, and RK 8605 x Mathura Rai, in pooled analysis. Among these hybrid combinations namely, RK 8902 x Laha 101, RK 8901 x Laha 101, RK 918506 x Mathura Rai, RK 8903 x Laha 101 and RK 911296 x Laha 101 were common in both the environments and pooled over the environments.

Hybrids virour over economic parents in case of yield per plant varied from –16.84 to 243.50 per cent consisting of 56 significant and positive hybrids at E_1, -26-13 to 2031.50 per cent with again 56 hybrids at E_2 and –18.03 to 237.56 per cent with 55 hybrids in pooled analysis. In 10 significant and positive economic heterosis, eight namely, KRV 47 x Laha 101, RK 8608 x Mathura Rai, RK 8604 x Vaibhav, RK 8801 x Mathura Rai, RK 8602 x Mathura Rai, RK 8601 x Laha 101, KRV 47 x Mathura Rai, and RK 14 x Mathura Rai, were common at both the environments and pooled over the environments. Out of these, 1st, 2nd and 3rd rankers were common at both the environments as well as on pooled basis.

In case of oil content, the range of heterosis over economic parent varied from –4.42 to 35.33 per cent with 50 significant and desirable hybrids at normal sown conditions (E_1), -2.71 to 21.66 per cent with 44 significant and desirable hybrids under at late sown situations (E_2) and –13.65 to 28.49 per cent with 49 significant and desirable hybrids in pooled analysis. Among these, seven hybrids namely, RK 918506 x Laha 101, RK 8602 x Vaibhav, RK 8604 x Mathura Rai, RK 8601 x Mathura Rai, RK 8601 x Laha 101, RK 8902 x Mathura Rai, RK 8803 x Vaibhav and RK 8604 x Vaibhav were common in both the sowing dates and pooled over these date of sowings. Again out of these the 1st and 2nd numbers

were the same at both the situations but the percentage of increase in hybrid vigour was higher in normal situation which was more that 10 per cent and the same increase was recorded in 10 hybrids in order of merit from E_1 to E_2.

In case of erucic acid, the range of heterosis over economic parent varied from –4.58 to 0.07 per cent with six significant and desirable hybrids at E_1 ; -5.26 to 0.28 per cent with 17 significant desirable hybrids at E_2 and –3.37 to 0.11 per cent with 12 significant and desirable hybrids in pooled analysis. Among these none were found common in both the environments except RK 8802 x Mathura Rai,.

Inbreeding Depression:

Estimates of inbreeding depression in F_2 over F_1 were calculated in terms of per cent for all the 13 characters individually for each sowing conditions and on pooled basis Negative values were considered as percent increase for days to flowing, height of plant, days to maturity and erucic acid while positive values were considered per cent decrease for other nine characters viz. days to reproductive phase, number of primary branches, number of secondary branches, length of main fruiting branch, number of siliquae of main fruiting branch, relative water content, leaf water potential, yield per plant and oil content.

Inbreeding depression was found to be significant and negative in 16 crosses at E_1, 10 crosses at E_2 and 7 crosses on pooled basis for days to flowering while the values ranged from –28.41 to 17.67 per cent and –20.79 to 26.39 per cent and –24.60 to 21.59 per cent, respectively of F_2 at each environment showing maximum depression, in order of ranking, were RK 14 x Vaibhav, RK 8801 x Mathura Rai, RK 8901 x Mathura Rai, RK 8702 x Vaibhav, RK 14 x Laha 101, RK 8802 x Mathura Rai, and KRV 47 x Laha 101 in E_1 ; RK 14 x Vaibhav, RK 8801 x Mathura Rai, RK 8901 x Mathura Rai, KRV 47 x Mathura Rai, KRV 47 x Vaibhav, RK 8801 x Laha 101 and RK 9002 x Mathura Rai, in E_2 ; RK 14 x Vaibhav, RK 8801 x Mathura Rai, RK 8901 x Mathura Rai, RK 9002 x Mathura Rai, KRV 47 x Vaibhav, RK 8801 x Laha 101 and RK 8602 x Mathura Rai, in pooled analysis. The common crosses RK 14 x Vaibhav, RK 8801 x Mathura Rai, and RK 8901 x Mathura Rai, were in both the environments and pooled over the environments.

Inbreeding depression for days to reproductive phase ranged from –14.00 to 14.52 per cent at E_1, 3.38 to 23.72 per cent at E_2 and –1.64 to 18.05 per cent on pooled basis seven F_2s at E_1, 51 F_2s at E_2 and 13 F_2s on pooled basis revealed significant and positive inbreeding depression. Seven F_2s showing depression, in order of sequence were RK 8701 x Mathura Rai, RK 8702 x Mathura Rai, RK

8605 x Laha 101, RK 8801 x Laha 101, RK 911296 x Mathura Rai, RK 911296 x Laha 101 and RK 8701 x Laha 101 in E_1 ; RK 918506 x Mathura Rai, RK 8605 x Laha 101, RK 911296 x Mathura Rai, RK 8903 x Laha 101, RK 911296 x Laha 101, RK 8701 x Laha 101 and RK 8702 x Laha 101 in E_2 ; RK 8605 x Laha 101, RK 911296 x Mathura Rai, RK 911296 x Laha 101, RK 8801 x Laha 101, RK 8802 x Laha 101, RK 8901 x Vaibhav and RK 8802 x Mathura Rai, in pooled analysis. Among these, RK 8605 x Laha 101, RK 911296 x Mathura Rai, and RK 911296 x Laha 101 were common in terms of environment wise as well as pooled over these environments.

The magnitude of inbreeding depression for number of primary branches varied from –33.33 to 59.45 per cent at E_1, -28.13 to 77.21 per cent at E_2 and –27.37 to 68.33 per cent on pooled basis exhibiting significant and positive inbreeding depression in 34 cases at E_1, 29 cases at E_2 and 25 cases on pooled basis. Ten F_2 progenies showing maximum depression (more than 45 per cent), in order of ranking were RK 8601 x Vaibhav, RK 8702 x Vaibhav, RK 8803 x Vaibhav, RK 14 x Laha 101, RK 918506 x Vaibhav, RK 8604 x Mathura Rai, RK 8801 x Mathura Rai, RK 8608 x Vaibhav and RK 14 x Vaibhav in E_1 ; RK 8601 x Vaibhav, RK 8803 x Vaibhav, RK 8608 x Mathura Rai, RK 8608 x Laha 101, RK 8702 x Vaibhav, RK 918506 x Vaibhav, RK 14 x Laha 101, RK 8801 x Mathura Rai, KRV 47 x Vaibhav and RK 9001 x Mathura Rai, in E_2 ; RK 8601 x Vaibhav, RK 8803 x Vaibhav, RK 8702 x Vaibhav, RK 8608 x Laha 101, RK 14 x Laha 101, RK 8801 x Mathura Rai, RK 8605 x Mathura Rai, RK 8608 x Vaibhav, RK 14 x Vaibhav and KRV 47 x Vaibhav in pooled analysis. Out of these, RK 8601 x Vaibhav, RK 8702 x Vaibhav, RK 8603 x Vaibhav, RK 14 x Laha 101 and RK 8801 x Mathura Rai, were common at both the sowing conditions and pooled over these environments.

The extent of inbreeding depression in case of secondary branches ranged from –42.61 to 62.83 per cent at E_1, -11.53 to 142.21 per cent at E_2 and –18.62 to 100.62 per cent on pooled basis indicating significant decrease in 34 combinations at normal sowing (E_1) ; 40 combinations at late sowing (E_2) and 35 combinations in pooled analysis. Ten cross combinations exhibiting significant decrease, in order of ranking, were RK 8601 x Vaibhav, RK 14 x Laha 101, RK 8608 x Vaibhav, RK 8608 x Mathura Rai, RK 8604 x Vaibhav, RK 8602 x Mathura Rai, RK 8802 x Mathura Rai, RK 8801 x Laha 101, RK 8902 x Laha 101 and RK 14 x Vaibhav in E_1 ; RK 8801 x Laha 101, RK 8601 x Vaibhav, RK 8608 x Mathura Rai, RK 8608 x Laha 101, RK 14 x Laha 101, RK 8604 x Vaibhav, RK 9 x Mathura Rai, RK 8601 x Mathura Rai, RK 8602 x Mathura Rai, and RK 9 x Laha 101 in E_2 ; RK 8601 x Vaibhav, RK 8608 x Mathura Rai, RK 8608 x Laha 101, RK 14 x Laha 101, RK 8604 x Vaibhav, RK 9 x Mathura Rai,

RK 8602 x Mathura Rai, RK 8601 x Mathura Rai, RK 9 x Laha 101 and RK 14 x Vaibhav on pooled basis. Out of these five combinations namely RK 8601 x Vaibhav, RK 14 x Laha 101, RK 8608 x Mathura Rai, RK 8604 x Vaibhav and RK 8602 x Mathura Rai, were common at both the environments and on pooled basis.

In case of height of plant, eight crosses revealed significant depression ranging from –28.39 to 17.93 per cent at E_1 while at E_2, it was 22 crosses with the range of –30.52 to 32.35 per cent. Pooled estimates reflected that nine crosses exhibited significant and negative inbreeding ranging from –27.51 to 23.23 per cent. Eight crosses in order of sequence were RK 8602 x Vaibhav, RK 14 x Laha 101, RK 91850 x Laha 101, RK 8601 x Laha 101, RK 911296 x Laha 101, RK 8604 x Mathura Rai, RK 8902 x Mathura Rai, and RK 8604 x Vaibhav in E_1; RK 918506 x Laha 101, RK 8604 x Vaibhav RK 8602 x Mathura Rai, RK 8602 x Vaibhav, RK 8701 x Mathura Rai, RK 8903 x Mathura Rai, RK 14 x Laha 101 and RK 9001 x Laha 101 in E_2 ; RK 918506 x Laha 101, RK 8602 x Vaibhav, RK 8602 x Mathura Rai, RK 911296 x Laha 101, RK 8701 x Mathura Rai, RK 8608 x Mathura Rai, RK 8803 x Mathura Rai, and RK 8702 x Laha 101 in pooled analysis. Among these, crosses RK 8602 x Vaibhav, RK 918506 x Laha 101 and RK 8601 x Laha 101 were common at both the environments and on pooled analysis.

Out of 60 F_2s for length of main fruiting branch, 45 crosses at E_1 33 at E_2 and 20 on pooled basis revealed significant decrease ranging from –24.69 to 57.47 per cent, -48.24 to 43.17 per cent and –15.41 to 47.62 per cent, respectively. Ten crosses showing depression, in order of merit, were RK 14 x Vaibhav, RK 8604 x Vaibhav, RK 8802 x Laha 101, RK 8902 x Vaibhav, RK 8803 x Vaibhav, RK 8702 x Vaibhav, RK 9002 x Laha 101, RK 8602 x Mathura Rai, RK 8601 x Vaibhav and RK 14 x Mathura Rai, in E_1; RK 8608 x Mathura Rai, RK 8802 x Laha 101, RK 8702 x Vaibhav, RK 14 x Vaibhav, RK 8601 x Laha 101, RK 8902 x Vaibhav, RK 8604 x Vaibhav, RK 8803 x Vaibhav, RK 8602 x Mathura Rai, and RK 9001 x Mathura Rai, in E_2, ; RK 8802 x Laha 101, RK 14 x Vaibhav, RK 8702 x Vaibhav, RK 8604 x Vaibhav, RK 8902 x Vaibhav, RK 8803 x Vaibhav, RK 9002 x Laha 101, RK 8602 x Mathura Rai, RK 8601 x Vaibhav and RK 14 x Mathura Rai, in pooled analysis, seven being common in both the environments as well as pooled analysis. These were RK 14 x Vaibhav, RK 8604 x Vaibhav, RK 8802 x Laha 101, RK 8902 x Vaibhav, RK 8803 x Vaibhav, RK 8702 x Vaibhav and RK 8602 x Mathura Rai, Number of siliquae on main fruiting branch revealed maximum inbreeding depression in 27 crosses each at E_1, E_2 and in pooled analysis with range of - 66.65 to 89.99 per cent at E_1, 35.43 to 44.32 per cent at E_2 and –51.04 to 35.10 per cent in pooled analysis. In

order of ranking the highest depression (more than 25 per cent) was observed in 10 crosses namely, RK 8702 x Laha 101, RK 8601 x Vaibhav, RK 8608 x Laha 101, RK 8604 x Vaibhav, RK 9001 x Mathura Rai, RK 8702 x Vaibhav, RK 8801 x Laha 101, RK 14 x Mathura Rai, RK 911296 x Vaibhav and RK 9001 x Vaibhav in E_1; RK 9002 x Laha 101, RK 9001 x Vaibhav, RK 8608 x Laha 101, RK 14 x Laha 101, RK 9002 x Vaibhav, RK 8601 x Vaibhav, RK 918506 x Laha 101, RK 8901 x Vaibhav, RK 8903 x Vaibhav and RK 8702 x Vaibhav in E_2 RK 8601 x Vaibhav, RK 9002 x Vaibhav, RK 9001 x Vaibhav, RK 9002 x Laha 101, RK 8608 x Laha 101, RK 8702 x Laha 101, RK 8702 x Vaibhav, RK 8903 x Vaibhav, RK 8604 x Vaibhav and RK 8801 x Laha 101, in pooled analysis. The common crosses were RK 8601 x Vaibhav, RK 8608 x Laha 101, RK 8702 x Vaibhav and RK 9001x Vaibhav at both the situations and pooled over these situations.

Inbreeding depression for days to maturity ranged from –13.89 to 26.81 per cent at E_1, -12.66 to 14.32 per cent E_2 and –6.21 to 18.48 per cent on pooled basis. twelve F_2s at E_1 and 2 each at E_2 and on pooled basis revealed significant and negative inbreeding depression. These in order of ranking were RK 8902 x Laha 101, RK 9002 x Laha 101, RK 8701 x Mathura Rai, RK 8801 x Mathura Rai, RK 8702 x Mathura Rai, RK 8801 x Laha 101, RK 8602 x Laha 101, RK 8608 x Mathura Rai, RK 8602 x Mathura Rai, and RK 8802 x Laha 101, in E_1; RK 911296 x Laha 101, RK 8702 x Vaibhav in E_2; RK 8602 x Laha 101, RK 9002 x Laha 101 on pooled basis. None were found common under these two planting situations.

Inbreeding depression for relative water content varied from –23.00 to 16.42 per cent at E_1, - 24. 78 to 14.33 at E_2 and 17.01 to 10.52 per cent in pooled analysis revealing significant and positive depression in 21,20 and 21 crosses respectively. The maximum reduction was recorded in 10 crosses in order of ranking and these were KRV 47 x Mathura Rai, RK 8803 x Laha 101, RK 8601 x Mathura Rai, RK 8903 x Laha 101, RK 8604 x Laha 101, RK 14 x Vaibhav, RK 9002 x Laha 101, RK 8605 x Mathura Rai, RK 8901 x Laha 101, and RK 9 x Laha 101in E_1 ; RK 8702 x Laha 101, RK 911296 x Mathura Rai, RK 8803 x Mathura Rai, RK 8802 x Laha 101, RK 8902 x Laha 101, RK 9001 x Laha 101, RK 9 x Mathura Rai, RK 8901 x Laha 101, RK 14 x Vaibhav and RK 8605 x Vaibhav in E_2 ; KRV 47 x Mathura Rai, RK 14 x Vaibhav, RK 8601 x Mathura Rai, RK 8903 x Laha 101, RK 8901 x Laha 101, RK 8602 x Mathura Rai, RK 9 x Mathura Rai, RK 8604 x Laha 101, RK 8605 x Vaibhav and RK 9002 x Laha 101 on pooled analysis. Two crosses namely, RK 14 x Vaibhav and RK 8901 x Laha 101 were common under both the situations and pooled over the situations.

Fourteen and 25 F_2 crosses revealed significant and positive inbreeding depression for leaf water potential under normal and late planting situations, respectively. Pooled estimates reflected significant and positive inbreeding depression for 17 F_2 progenies. The range of depression was –105.76 to 52.49 per cent under normal planting, 44.37 to 51.65 per cent under late planting and 72.94 to 43.51 per cent in pooled analysis. Out of these two date of plantings the maximum reduction was recorded in 10 crosses (more than 12 per cent) and these in order of ranking were RK 8902 x Laha 101, RK 918506 x Mathura Rai, RK 8601 x Vaibhav, RK 911296 x Laha 101, KRV 47 x Mathura Rai, RK 8801 x Laha 101, RK 9002 x Laha 101, RK 8601 x Mathura Rai, RK 8903 x Mathura Rai, and RK 8701 x Laha 101 in E_1 ; RK 8902 x Laha 101 , RK 8901 x Laha 101, RK 918506 x Mathura Rai, RK 14 x Mathura Rai, RK 8903 x Laha 101, RK 8601 x Laha 101, RK 8802 x Mathura Rai, RK 911296 x Laha 101, RK 8901 x Mathura Rai, and RK 8601 x Mathura Rai, in E_2 ; RK 918506 x Mathura Rai, RK 8601 x Vaibhav, RK 911296 x Laha 101, RK 8604 x Vaibhav, RK 8601 x Mathura Rai, RK 14 x Mathura Rai, RK 8601 x Laha 101, RK 8901 x Mathura Rai, RK 14 x Laha 101, and RK 8701 x Mathura Rai, in pooled analysis. The cross combinations, RK 911506 x Mathura Rai, and RK 911296 x Laha 101 were common among these combinations at both the environments and pooled over the environments.

In case of yield per plant 47 crosses at E_1, 54 crosses at E_2 and 55 crosses on pooled basis exhibited significant and positive inbreeding depression. The range of such depression was from –37.69 to 74.92 per cent at E_1, -49.48 to 231.59 per cent at E_2 and –27.47 to 153.25 per cent at pooled analysis. Ten combination showing maximum depression (more than 50 per cent) for this attribute, in order of sequence, were KRV 47 x Laha 101, RK 8604 x Vaibhav, RK 8608 x Vaibhav, RK 8601 x Vaibhav, RK 9001 x Mathura Rai, RK 8608 x Mathura Rai, RK 8602 x Mathura Rai, RK 14 x Laha 101, RK 8602 x Vaibhav and RK 8702 x Vaibhav in E_1 ; KRV 47 x Laha 101, RK 8608 x Mathura Rai, RK 8604 x Vaibhav, RK 8801 x Mathura Rai, RK 8602 x Mathura Rai, RK 8601 x Laha 101, RK 8605 x Laha 101, KRV 47 x Mathura Rai, RK 14 x Mathura Rai, and RK 8608 x Vaibhav in E_2 ; KRV 47 x Laha 101, RK 8608 x Mathura Rai, RK 8801 x Mathura Rai, RK 8604 x Vaibhav, RK 8602 x Mathura Rai, RK 8608 x Vaibhav, RK 8601 x Laha 101, RK 14 x Mathura Rai, RK 8605 x Laha 101 and RK 911296 x Mathura Rai, in pooled analysis. Five crosses namely, KRV 47 x Laha 101, RK 8604 x Vaibhav, RK 8608 x Vaibhav, RK 8608 x Mathura Rai, and RK 8602 x Mathura Rai, were common at both the environments and pooled over the environments in case of 10 significant and positive inbreeding depression.

Oil content revealed maximum depression in 25 crosses at E_1 , 16 crosses at E_2 and 13 crosses in pooled analysis with the range of –29.41 to 21.89 per cent in E_1, -4.45 to 19.37 at E_2 and –15.79 to 17.76 per cent in pooled analysis. In order of ranking, the highest depression (more than 11 per cent) was observed in 10 crosses such as RK 8701 x Mathura Rai, RK 8608 x Mathura Rai, RK 8604 x Vaibhav, RK 8902 x Mathura Rai, RK 8602 x Mathura Rai, RK 8902 x Laha 101, RK 8701 x Vaibhav, RK 8601 x Laha 101, RK 9001 x Laha 101 and RK 8602 x Vaibhav in E_1 ; RK 8602 x Vaibhav, RK 8602 x Mathura Rai, RK 8604 x Mathura Rai, RK 8601 x Mathura Rai, RK 8601 x Laha 101, RK 8902 x Mathura Rai, RK 911296 x Laha 101, RK 8803 x Vaibhav, RK 8604 x Vaibhav and RK 9001 x Laha 101 in E_2 ; RK 8701 x Mathura Rai, RK 8608 x Mathura Rai, RK 8902 x Mathura Rai, RK 8604 x Vaibhav, RK 8602 x Mathura Rai, RK 8601 x Laha 101, RK 8602 x Vaibhav, RK 918506 x Laha 101, RK 8902 x Laha 101 and RK 9001 x Laha 101 in pooled analysis. Among these, six crosses namely, RK 8604 x Vaibhav, RK 8902 x Mathura Rai, RK 8602 x Mathura Rai, RK 8601 x Laha 101, RK 9001 x Laha 101 and RK 8602 x Vaibhav were common at both the environments and in pooled analysis.

Inbreeding depression for erucic acid varied from –0.57 to 3.46 per cent at E_1, - 8.48 to –0.89 per cent in E_2 and – 0.81 to 3.38 per cent in pooled analysis revealing significant and negative depression 3 crosses in E_1 11 crosses in E_2 and 7 on pooled basis indicating late planting might result in the development of low erucic acid content.

HERITABILITY AND GENETIC ADVANCE:

Habitability:

Estimates of habitability were carried out in narrow sense with regard to all the 13 attributes separately for normal and late sowings and pooled over these two environments in both F_1 and F_2 generations. The findings on this aspect directly related to selection are presented in Table 9. The values of narrow sense heritability were usually arbitrarily and reasonably, it was catogarised in three distinct classes such as high heritability (above 30%), moderate heritability (above 10% and below 30%) and low heritability (below 10%).

The observation on Table 9 revealed high heritability for days to flowering, height of plant, day to maturity and erucic acid in both the generations in both the environments, days to reproductive phase in F_1 in both the environments and days to reproductive phase in F_2 in normal sowing.

Moderate heritability in both F_1 and F_2 generations as well as in both the environments was recorded for number of secondary branches, length of main fruiting branch and leaf water potential. Moderate values for this parameter were observed for days to reproductive phase, relative water content and oil content in F_1 while in F_2 number of primary branches and yield per plant revealed the same performance pooled over the environments.

Other attributes either in F_1 or in F_2 or in pooled over both the environments exhibited low degree of heritability.

Genetic Advance:

Genetic gain was estimated as genetic advance in per cent of mean in F_1 and F_2 generations with regard to all the 13 attributes in both the environments separately as well as pooled over the environments. The results on this direct selection parameter are presented in Table 9.

The perusal of Table 9 revealed that genetic gain was in the range of high to low in both the generations and pooled over the generations. The genetic gain in per cent of mean was high for number of secondary branches pooled over both the environments in F_1 generations.

Moderate genetic gain was recorded in days to flowering, height of plant, length of main fruiting branch, leaf water potential and yield per plant in both the generations as well as pooled over the environments; number of primary and secondary branches in F_2 and pooled in both the environments of F_2.

Low estimates of genetic advance in per cent of mean were recorded for erucic acid, oil content, relative water content, days to maturity, number of siliquae on main fruiting branch, length of main fruiting branch and days to reproductive phase in both the generations and number of primary branches in F_1.

CORRELATION COEFFICIENTS AND PATH COEFFICIENTS ANALYSIS

Correlation Coefficients:

Estimates of phenotypic and genotypic correlation coefficients amongst 13 agronomical and biochemical attributes were worked out separately in F_1 and F_2 generations as well as pooled over the environments. The results for F_1s and F_2s are presented in Table 10 A and 10B respectively for all the 78 combinations. In general, the magnitude of coefficient at genetic levels was higher than their corresponding phenotypic ones.

The data revealed significant association in 36 character combinations in $F_1$and 31 character combinations in F_2 at pooled basis. Among these, 26 character combinations were common in both the generations.

In F_1 generation pooled over both the environment, seed yield revealed significant and positive association with number of primary branches, number of secondary branches, number of main fruiting branch, days to maturity, and oil content at phenotypic level. These values were higher at genotypic level too. Negative significant correlations were recorded between yield with days to flowering, plant height and erucic acid.- All these association with grain yield were desirable at both genotypic and phenotypic levels.

Days to flowering revealed negative and significant association with days to maturity and yield per plant while it was positive with erucic acid. Days to reproductive phase was found to be significantly and positively associated with number of siliquae on main fruiting branch, relative water content and oil content, all these associations were in desirable direction. Erucic acid exhibited significant and negative association with days to reproductive phase indicating shorter grain filling period was associated higher erucic acid content.

Number of primary branches showed significant and positive association with number of secondary branches, number of siliquae on main fruiting branch and yield per plant. Negative and significant association was recorded between number of primary branches and erucic acid which are also desirable.

Number of secondary branches revealed significant and positive association with number of siliquae on main fruiting branch, days to maturity, leaf water potential, yield per plant and oil content, reflecting desirable correlated response with these attributes.

Length of main fruiting branch was found to be significantly and positive associated with number of siliquae on main fruiting branch, negative and significant association were recorded between length of main fruiting branch with leaf water potential, yield per plant and oil content.

Number of siliquae on main fruiting branch revealed significant and positive associations with six attributes namely, days to reproductive phase, number of primary branches, number of secondary branches, height of plant length of main fruiting branch and yield per plant exhibiting desirable correlated response with yield per plant.

Days to maturity showed positive and significant association with number of secondary branch and number of siliquae on main fruiting branches while

negative and significant association of this character was recorded with days to flowering and oil content.

Relative water content exhibited positive and significant association with days to reproductive phase, leaf water potential, yield per plant and oil content. All these association were in desirable direction.

Leaf water potential was associated positively and significantly with number of secondary branches, days to maturity, yield per plant and oil content indicating desirable associations with these attributes.

Oil content was positively and significantly associated with five characters. These were days to reproductive phase, number of secondary branches, days to maturity, leaf water potential, yield per plant, height of plant, number of siliquae on main fruiting branch and erucic acid indicated negative and significant association with oil content. Both types of association (positive and negative) with oil content were in favourable and desirable direction, hence, these characters could be taken as selection criteria in the field itself for increasing the oil content.

Erucic acid was associated significantly and negatively with days to reproductive phase, numbers of primary branches, number of secondary branches, days to maturity, yield per plant and oil content. Among these desirable associations of this traits were with seed yield, oil content and days to maturity. Moreover, erucic acid content showed positive and significant association with days to flowering again a desirable association, thus developing early flowering genotypes with less erucic acid was possible with these material.

In F_2 generation pooled over both the environments, the direction of the association was the same but the values were fluctuating and some of the associations did not response significant from F_1 to F_2 generation.

In F_2; yield per plant revealed positive and significant association with number of primary branches, number of secondary branches, length of main fruiting branch, relative water content and oil content while significant and negative associations were with days to flowering, height of plant and erucic acid. All these positive and negative associations with yield were in desirable direction indicating simultaneous selection of these attributes might result in correlated response for better productively.

Oil content was positively associated with days to reproduction phase, number of secondary branches, days to maturity, leaf water potential and yield per plant where as negative association between oil content and days to flowering,

height of plant and erucic acid were desirable ones, Positive and significant association of erucic acid with days to flowering, number of primary branches, length of main fruiting branch and number of siliquae on main fruiting branch were observed.

Number of secondary branches was associated with number of primary branches, number of siliquae on main fruiting branch and oil content in positive direction indicating desirable correlated response for increasing both yield per plant and oil content.

Height of plant was negatively and significant association with yield per plant reflecting desirable association for increasing yielding ability with dwarf plant type.

The findings on path coefficient analysis (direct and in direct effects) at genotypic and phenotypic levels for oil yield Vs Other 12 attributes in two environments (E_1 and E_2) along with their pooled values in F_1s and F_2s (Table 10C and 10D) of Indian mustard were taken in discussion part of this dissertation.

CHAPTER 5

DISCUSSION

DISCUSSION

The ultimate objective of most of the plant breesding programme is to develop high yielding genotypes/varieties better than existing ones through the manipulation of genetic variability. Yield is a complex character comprising of number of components most of which are under polygenic control and therefore, are very susceptible to environmental fluctuations. However, Grafius (1964) pointed out that "there is no way in which yield can be changed without changing one or more of the components". He further pointed out that "while all changes in yield might be accompanied by change in one or more of the components, all changes in the components need not be expressed in changes in yield". This is due to varying degree of positive or negative correlations between yield and its components on one hand and between the components themselves on the other, such that gains made through selection in favour of one component are offset by reduction in others. The knowledge of the amount of genetic variability exiting in the material, the type of gene action governing yield and its components and a clear understanding of other genetic parameters are essential for successful exploitation of available or artificially created genetic variability and formulation of planned breeding programmes for the development of better genotypes of desired economic value.

Jinks and Jones (1958) pointed out that high degree of yield potential could result from a combination of gene effects. Gamble (1962) inferred that consistency of such gene effects depended on the number of genes involved in the inheritance of quantitative character. The opportunity for influence by the environments becomes more when the gene number is increased. The characters having more loci for their expression exhibit considerable genotype-environment interactions. It has further been advocated that in self-fertilizing crops like Indian mustard, high yield is due to the operation of additive gene complexes, and thus, the additive genetic variance is more important. The combining of additive genes together by hybridization of diverse genetic material having desirable characters from diverse origin and subsequent selection with adequate selection intensities could result in the improvement of such population.

Joshi and Dhawan (1966) concluded in their studies that autogamous mating system in self-fertilizing crops has placed a restriction of breeding of these crops in respect of utilizing evolutionary breeding methodology of cross fertilizing crops since inbreeding leads to rapid fixation of genotypes, precludes the free exchange of favorable genes between different individuals in the population, restricts recombination and prevents the emergence of desirable gene constellation. Due to these limitations, the progress in breeding for yield in self-

fertilizing crops has been relatively slow and the gains in yield have largely been achieved through the removal of bottlenecks to production by the manipulation of oligogenically controlled characters. The main features of the breeding methodology in these species have been the selection of parents for hybridization on the basis of per se performance for yield and other characters, followed by individual plant selection in segregating generations. It is, therefore, essential that this approach be reoriented so as to formulate yield breeding programme in which the choice of the parents is based not only on the desirable agronomic characters but also on the combining ability, genetic analysis of yield and yield contributing characters.

Several mating designs have been used to determine the breeding value of genotypes and the nature of gene action governing various quantitative characters. Line x tester mating design developed by Kempthorne (1957) is useful to evaluate large number of lines at a time. Due to this advantage, the technique has been used in Indian mustard by Lal and Singh (1974), Pandey (1974), Badwal *et al.* (1976), Yadav *et al.* (1979 a,b,), Labana *et al.* (1978 b) and Singh (1995).

Due to wide genetic variability prevalent in this crop, the information already available on various genetic parameters from one set of material could not be applied to the other. It was, therefore, essential to evaluate more and more genotypes/lines for their breeding values and understanding other genetic parameters related to yield and its components in order to formulate an efficient hybridization programme.

Undoubtedly, substantial improvement in yield and concomitant increases in net returns should be achieved through breeding cultivars that are better adapted to late sown climatic conditions. Therefore, studies are to be initiated with the primary objective of developing breeding methods which would facilitate the rapid attainment of these yield improvements Significant improvements in crop yield have, of course, been obtained through breeding, despite a limited understanding of low yield is inherited on what physiological characters of plant determine potential yield. At the present time, however, it is recognized that a reassessment of traditional breeding methods based on information from biometrical and physiological studies of crop yield is essential if further worth- while gains in the yielding capacity of the crops are to be achived. Such reassessments have prompted proposals regarding improved methods of generating and manipulating variation in genetic population as well as consideration of new selection criterion based on physiological character (Frey, 1971). Although these reappraisals of breeding methods have been largely confined to intensively bred crop in which decling selection response have been a cause of concern, the underlying principle are pertinent to any crop improvement

programme. The feasible way, however, is to examine the variation in physiological traits using a range of genotypes and to determine whether any physiological aspects or traits predominates in the high yielding types. Results obtained from this approach have wide applications as pointers for detailed physiological analysis.

Considerable progress has been made in the understanding of physiological and metabolic changes brought about by water stress (Haine, 1975) and effects of these physiological changes on crop growth and yield (Begg and Turner, 1976). It has been shown that the physiological responses of plant to terminal heat tolerance and the many characters implicated in heat resistance are extremely complex and vary with the type of plant as well as the extent and time of exposure to heat.

Heat resistance is the result of many frequently independent, morphological and physiological characters whose interactions have not yet been fully elucidated. Most of these characters are under polygenic control and, probably, exhibit consideration genotype-environment interactions (Richards, 1978). It is little surprise, therefore, that plant breeders have not been fully successful in breeding specifically for heat resistance through selection based on physiological processes (Ashton, 1948; Moss *et al.* 1974; Hurd, 1976). Nevertheless, with a thorough understanding of the genetics of the physiological responses involved and with due consideration given to the growth and development of a particular crop and the region in which it is to be grown, the isolation of heat tolerance lines should be possible, when grown under late sown situations.

The next important feature of these lines should be their adaptability to diverse environments. Adaptability refers to ability of crops to survive and reproduce in diverse environments. Recent references actually mean more than natural wide adaptation. There is a definite expectation of the crops performance in relation to the environmental worth specifically that crop yield increases with improvement in environmental factor related to yield. The fell-need objective, however, is to develop a feasible and straight forward methodology to identify cultivars that are adaptable to a wide range of environments.

Keeping the afore-mentioned considerations in view, the present investigation in Indian mustard (B. juncea)was undertaken using 23 diversified varieties / strains (20 Lines and 3 Testers) in the line x tester mating design to determine the nature and magnitude of gene action and its interaction with environments, combining ability effects, heterotic and inbreeding depression, heritability and genetic advance, phenotypic and genotypic correlations as well as

direct and indirect effects (path coefficient values) for 13 quantitative characters in two environments viz; normal and late sown conditions.

Considering the importance of physiological criteria that may complement more conventional breeding methods has ten improvement in heat tolerant conditions (Stone, 1975; Turner, 1979), two traits each for physiological and quality (oil content and erucic acid) were included in the study in both the environments.

The genotypes that were investigated in present study were principally selected for high yield under different conditions and on the basis of the in adaptability to heat tolerant situations in the case of male genotypes (testers). Although these genotypes originated from a limited number of parents, considerable fluctuations in the range of adaptation irrespective of their history of selection were observed.

The practical importance of the findings derived from this investigation is discussed below:

GENETIC COMPONENTS AND COMBINING ABILITY FOR YIELD :

The fundamental objectives of plant breeding is to develop genotypes/ varieties that combine productivity with other desirable attributes both under favourable and stress (late) environmental conditions. However, the superiority of the improved types is caused by certain specific gene combinations and how rapidly these specific gene combinations can be marshalled in a single plant or variety depends on the system through which the genes in the material available are mobilized. For a plant breeders, therefore, the characterization of the genetic architecture (nature and magnitude of gene action) of the population that is dealing with, and the understanding of the system into which the genes are incorporated in these population, is of paramount importance in the formulation of any coherent hybridization programme.

The combining ability analysis through line x testers technique was undertaken using methodology of Kemthorne (1957) which involves the study of covariances of full-sibs and covariances of half-sits to get the estimates of gca and sca variances and their effects. These were worked out separately for F_1 hybrids and F_2 progenies (locationwise as well as on pooled basis). This technique is based on the general structure of the experiment with the following expectation.

(i) The individual within a plot resulting from crosses are full-sibs,

(ii) The individual in different replicates resulting from a particular cross are full-sibs; and

(iii) The individual in the same or different replicates resulting from a common tester (sire) but different lines (daws) are half-sibs.

Additive genetic variance results mostly from additive gene action. Non-additive genetic variance is made up of dominance and epistatic variances. The dominance variance diminishes by half with each generation of selfing and is, therefore unexploitable in the development of fixed line(s). The epistatic variance also declines on selfing, but some of it is fixable like additive x additive, additive x additive x additive etc. type of epistasis. When hemozygous lines are used, the components $\hat{\sigma}^2_g$ and $\hat{\sigma}^2_s$ are equal to $^1/_2\,\hat{\sigma}^2_A$ and $\hat{\sigma}^2_D$, respectively, with disomic inheritance in the absence of epistasis; however, when non-inbred parents are used, the same components are equal to $^1/_2\,\hat{\sigma}^2_A$ and $^1/_4\,\hat{\sigma}^2_D$.

In addition to other genetic parameters, the average degree of dominance is also of interest to plant breeders. The degree of dominance has been estimated as $(\hat{\sigma}^2_D\ /\ \hat{\sigma}^2_A)^{1/2}$. This formula is based of the assumption that the genes are isodirectionally distributed among the parents and all the increments have the same sign (Kempthorne and Curnow, 1961). This procedure, thus measures only the degree of dominance regardless of direction. If the dominance variance is in the plus or minus directions they tend to cancel each other, and then F_1 may be equal to the mean of its better parent.

Analysis of variance for combining ability (Table 5) revealed significant differences among female and male genotypes for all the 13 characters in both the generations and environments. The two physiological characters, also exhibited highly significant differences due to females and males (Table 5). The interaction between, males and females showed highly significant differences for all the 13 characters.

The genotypes revealed significant interaction with the environments for all the 13 characters that were studied in two environments. This was expected because the environment represented a wide variation in temperature during sowing times. The importance of genotype x environment interactions has been reported in may crops and ommission of such an interaction in any genetic study is likely to result in erroneous conclusions (Allard and Bradshaw, 1964; Comstock and Moll, 1963). The present findings were obtained from two different environments and, thus, the estimates drawn from them might not incorperate a biased estimate except the one from entries years interaction. However the selected environments were diverse inrespect and, therefore, the

estimates were not likely to cause much upward bias from such interactions. Comstock and Moll (1963) were of the opinion that comparison of estimates for data obtained from the same year were more meaningful than comparison of estimates from different years.

The estimates of components of genetic variance (Table5) due to $\hat{\sigma}^2_A$ and $\hat{\sigma}^2_D$ incicated that both additive and non-additive gene actions were responsible for the inheritence of all the traits including two each for physiological and quality attributes but the non-additive gene action seemed to be more important than the additive gene action in both the generations for all the characters except erucic acid. Such findings for gene action were reported by Singh *et al.* (1972). Tiwari and Singh (1973, 1975). Tiwari *et al.* (1977), Labana *et al.* (1978b), Pal *et al.* (1981b) and Singh *et al.* (1985) for days to flowering. Wani and Srivastava (1989) for days to reproductive phase; Labana *et al.* (1978a & b), Paul (1978, 1979), Chauhan and Singh (1979), Singh *et al.* (1981, 1985), Gupta *et al.* (1987), Thakur *et al.* (1989), Wani and Srivastava (1989), Dhillon *et al.* (1990) and Patel *et al.* (1993) for number of primary and number of secondary branches. Tiwari and Singh (1973, 1975), Ram *et al.* (1976), Tiwari *et al.* (1977). Asthana and Panday (1977), Gupta *et al* ((1987), Thakur *et al.* (1989) and Dhillon *et al.* (1990) for height of plant; Yadav *et al.* (1977) Chauhan and Singh (1979), Singh *et al.* (1985). Gupta *et al.* (1987), Wani and Srivastava (1989) and Dillon *et al.* (1990) for length of main fruiting branch; Paul *et al.* 91976b) Yadav *et al.* (1977), Paul (1979) Singh *et al.* (1981, 1985) Gupta *et al.* (1987) Verma *et al.* (1988) Patel *et al* (1993) and Singh *et al.* (1996) for number of siliquae on main fruiting branch; Singh *et al.* (1985) for days to maturity; Wani and Srivastava (1989) for both the relative water content and leaf water potential.

For grain yield per plant pre-dominantly non-additive genetic component was observed by Labana *et al.* (1978), Pal and Singh (1980), Singh *et al.* (1981, 1982), Thakur *et al.* (1989),Varsheny *et al.* (1990), Similarly for oil content Pal and Singh(1980), Dixit *et al.* (1983), Govil *et al.* (1983), Pal *et al* (1983) Hu (1988), Prakash *et al* (1988), Singh and Yash Pal (1991), reported pre- dominance of dominance and non- additive genetic component. Additive and non-additive genetic components were reported by large number of workers like Tiwari and Singh (1975),Tiwari *et al* (1977), Yadav *et al.* (1977), Labana *et al.* (1978a), Anand and Rawat (1978), Chauhan and Singh (1979), Paul (1979), Singh *et al.* (1985), Gupta *et al.* (1987), Wani & Srivastava (1989), and Dhillon *et al* (1990) for yield per plant; Yadav and Singh (1975), Grami and Stefansson (1977), Yadav *et al* (1981a, 1981b), Kumar *et al.* (1985), Badwal and Labana (1988), Prakash *et al.* (1988), Wani and Srivastava (1989), Pal and Kumar (1991) and Yadav *et al.* (1992) for oil content. Eruic acid was reported to control by additive

genetic component as reported by Kondra and Stefansson (1965), Lutfur (1976),Liv and Liv (1989).

The degree of dominance was in the over dominance for all these characters except erucic acid in both the generations. Over dominance was also reported for the expression of these characters in most of the studies reported above in 12 out of 13 characters under present investigation. Erucic acid was controlled by particle dominance as reported by lutfur (1976).

The variances due to sca were considerably greater in magnitude than corresponding gca variances in both the generations for two physiological characters viz; leaf water potential and relative water content, indicating therefore, the importance of non- additive gene action for the control of these characters. The degree of dominance exhibited over dominance for these characters in both the generations.

The discripancies observed in the results on the nature of gene action reported by different workers might be due to the differences in the selection of parental material, diversity in the material, population size, design adopted and the environmental conditions in which the experiment was conducted.

It was seen that 12 out of 13 characters showed over dominance in both the generations. The over dominance observed might not be an index of real over dominance at genetic level because combinations of positive or negative genes or complementary type of gene interaction of simply correlated gene distributions might seriously inflate the mean degree of dominance and convert partial dominance into perceptible over dominance (Hayman,1954). The average degree of dominance in the range of over dominance results from repulsion phase linkage of genes in the partial or complete dominance range. Experimental evidence indicating linkage bias was proved by Comstock *et al.* (1957). Gardnera and Lonnquist (1959), Robinson *et al.* (1960), Robinson and Moll (1963), Moll *et al.* (1964) and Willimas *et al.* (1965). The evidence was obtained by making simultaneus estimates in F_2 crosses and in advance generations obtained by randam mating .

The differences in the magnitude of gene action in F_1 and F_2 population in both the environments for some of the characters under study might largely be attributed to existence of linkages. According to our genetic knowledge, the estimates of variances due to additive gene action should increase in F_2. The increase or decrease in the estimate of variance due to non-additive genetic portion depends primarily on its nature in segregating population. For instance, if additive x additive type of gene action is responsible for higher value of non-

additive variance, it is obvious that magnitude of sca variance would not decline in F_2. However, if the estimates of sca variance are high due to larger contribution of dominance x dominance type of gene action, the magnitude is likely to decreance in F_2. But the decline in segregating generation would depend on the strength of linkage. When there is weak linkages, the possibility of fast declining of non-additive type of gene action is more. Robinson *et al.* (1960) stated that if there was preponderance of repulsion phase linkages, additive genetic variance could increase as the generations were advanced and if the linkage phase was predominantly coupling, additive genetic variance could decrease. The segregating generation is naturally more susceptible to genotype-environment interactions due to the presence of heterogygosity in the population than F_1 generation which is genetically uniform. It indicates that the estimates in the F_2s are likely to be more biased than these of F_1s. The estimates of variance in F_1s were more reliable also because, in the segregating generation, the genetic interactions too contribute towards dominance, thus causing inflation in estimates.

Most of the characters exhibited preponderance of non-additive genetic variation in both the generations and environments except erucic acid which exhibited prevalence of additive gene action. Such results indicate. That the genetic gain in these characters would be difficult by selection, and that non-additive genetic variance should be exploited through heterosis breeding.

The presence of predominantly large amount of non-additive genetic variance would necessiate the maintenance of heterozygosity in the population. But it is well know that there are no practical means for hybrid seed production in the case of Indian mustard on commercial scale. In such a situation, the non-additive genetic variability can be exploited by recurrent or modified recurrent selections. These procedures, although pose difficulties in self-pollinating crops have the promise to furnish encouraging results (Andrus, 1963; Singh, 1974). The recurrent selection has extensively been used in cross-pollinated crops. Nevertheless, there is no genetic reason to exclude its use in self- pollinated crops. The main handicap of using this methodology in self-pollinated crops. The main handicap of using these methodology in self pollinated crops, however is the difficulty in making sufficient crosses to initiate recombination portion in each cycle.

The additive portion of genetic variability observed for some characters in the present study can be made use of by simple breeding procedure, such as, pedigree method, involving selection based on progeny performance. However, it has generally been advocated that additive genetic variances in self-pollinated crops fix rapidly after F_2 generation resulting in restricted recombination. The breeding methodology, based on intermating in F_2 population as suggested by

Hanson (1959), and Miller and Rawlings (1967) in self-pollinated crops would appear more promising.

Rachei and Gardner (1975) presented the use of population breeing concept for the improvement of partially open-pollinated species through the utilization of additive gene effects. Frey (1975) indicated the use this technique in highly self-pollinated crops too. But major limitations in self-fertilizing crops like Indian mustard are the difficulty of infusing massive gene flow during the recombination phase and the limitations of having sufficient quantity of seeds for multilocational testing under several environments. However, these difficulties can be over come by increasing the rapidity and efficiency of manual hybridization, introducing some form of out crossing like genetic male sterility with a specific restorer, delayed dehiscence or protogyny into the population and reducing seed number and plot size required for testing.

In Indian mustard, seed production can be made fessible by the use of inducedmale sterility, self-incompatibility (Singh, 1959, 1961), advanced stigma mutant (Singh 1959; Asthana and Singh 1964, 1973) or other systems which ensure hybrid seed production.

Singh and Singh (1972) suggested that for the population improvement of Indian mustard, selected procedure, which should allow inter-mating of improved genotypes in successive generations be adopted. Singh (1973) suggested that in Indian mustard, rapid progress could be made by family selection involving occasional intermitting in subsequent generations. This might prove more effective than conventional procedure of mass or pedigree selection both in fixing and increasing the frequency of pleiotropic genes and chromosomal blocks of favourably linked genes in superior lines.

PERFORMANCE OF PARENTS AND THEIR CROSSES IN RELATION TO BREEDING OF INDIAN MUSTARD:

The knowledge of combining ability effects of parents and their crosses together with the *per se* performance of the crosses is of paramount importance to the breeders, because it assists them in the isolation of suitable germaplasm base for use in the subsequent breeding programme.

In the present investigation, the parents were observed to differ significantly in their gca effects, and none of them was found to be a good combiner for all the characters (Table 6) in both the generations as well as in both the environments.

The parents which had the highest magnitude of desirable gca effects common in both generations (F_1 and F_2) and environments (E_1 and E_2) were RK 8605 and RK 8602 for early flowering; RK 9001, RK 911296, RK 14, and RK 8608 for days to reproductive phase; RK 9001, RK 911296, RK 14, RK 8608 and RK 8902 for number if primary branches; RK 14, and RK 9002 for number of secondry branches; RK 8601, RK 8605, RK 9001 and RK 8702 for length of main fruiting branch; RK 8701, RK 8901 and RK8702 for number of siliquae on main fruiting branch; RK 8701 for days to maturity. The parents which exhibited significant and desirable performance in both the generations and environments for physiological traits were RK 8702, RK8601, RK 8801, RK 8701 and RK8604, for relative water content and RK 8601, RK8903, RK 8702, RK 9001 and Mathura Rai for leaf water potential. For yield per plant, the desirable and significant parents for gca were RK 8702, RK911296, RK8802 and RK 8701 while for oil content, parents RK 8901, RK 9001, RK 8605 and RK 8704 were best general combiners in both the generations and environments. Parents RK 8801,RK 8903, RK8901 and RK 14 were good general combiners for erucic acid in both generations and environments.

It was observed that strain RK 9001 which exhibited gca effects in F_1 and F_2 generations for primary branches, also exhibited significant and positive effects for days to reproductions phase, relative water content, leaf water potential in both the generations, besides being a good combiner for oil content. RK 8901 was a good combiner for number of siliquae on main fruiting branch and oil content.

It was observed that strain RK 8702 which exhibited high gca effects in $F_1$and F_2 generations for number of siliquae on main fruiting branch also exhibited significant and positive effects for length of main fruiting branch and leaf water political besides being a good general combiner for yield per plant. Another parent RK 8901 which possessed best gca effect for number of siliquae on main fruiting branch also possessed best gca effect for length of main fruiting branch, days to reproductive phase and oil content being best general combiner for erucic acid. Parent RK 8701 was a good general combiner not only for number of siliquae on main fruiting branch but also for relative water content, days to maturity (early) and yield per plant. Likewise RK 14 was a best general combiner for both number of primary and secondary branches but also good combiner for days to reproductive phase and plant height, RK 8605 was best general combiner for oil content as well as best general combiner for earliness and dwarf plant type in both the generations. Consequently they could be considered simultaneously while formulation a breeding programme for the improvement of dwarf type prossessing earliness and high oil content.

Parents that exhibited significant and desirable gca effects for yield per plant were also found to exhibit desirable performance for leaf water potential and relative water content in both the generations. These parental genotyoes would be of immense use if involved in hybridization programme which specifically envisages breeding varieties for heat tolerance during growth and grain development under late sown situations.

When all the characters were considered with equal weightage 10 parents namely, RK 8702, RK 8904, RK 14, RK 8701, RK 8601, RK 8605, RK 8608, RK 8802, RK 9001, and RK 911296 appeared to be promising on for three or more attributes on the basis of their gca effects in both the generations.

The gca effects for different characters of economic importance are useful for selecting parents with favorable genes for different components of yield. The gca effects include additive and additive x additive components of gene action (Griffing, 1956a, 1956b; Sprague, 1966) which represents fixable genetic effect, Gilbert (1967) also stated that the additive parental effects as measured by gca effects are of practical use to the plant breeder, whereas, non-allelic interactions are not predictable and can not be easily manipulated.

It is obvious from the present study, that the improvement in yield and characters associated with terminal heat tolerance can be achieved through hybridization by using good general combiners. Making use of aforementioned ten parents, that were good combiners for several characters, in a multiple crossing programme or in an intermating population involving all possible crosses among them subjected to biparental mating, may be expected to offer the maximum promise in breeding for high oil yield and terminal heat tolerance. Richards and Thurling (1979) in rapeseed reported that breeding for high yielding crops for heat tolerance has been predominantly emperical by selecting directly for yield contributing traits like early growth vigour, higher reproductive phase with early maturity followed by more number of primary branches instead of secondary branches.

In recent years, however, considerable attention has been given to physiological criteria that may complement more conventional breeding methods and hasten yield improvement in varying degree of temperature specially under delayed sowings (Stone, 1975,Turner, 1979). The advantage of these criteria, apart from their being simply incurred attributes, are that they would increase seed yields under temperature stressed situations as well as under favorable conditions. Nevertheless, increasing early growth rates in conditions where temperature is decreasing later in the scason may hasten the period of growth when temperature is high during grain formation becomes more obvious and

some compromise may be required (Richards and Thurling, 1978). It was shown in studies on swede rape that the predicted advance in yield in droughted environment was greater then the environment where temperature was not limiting or when yield was expressed as temperature responce (Richards, 1978).

Jensen's (1970) scheme of diallel selective mating system for cereal breeding which offers breeders to incorporate broader germplasm base into breeding projects, can also be employed successfully for the present material. This method provides to combine the favorable gene or gene complexes and to break tight linkages due to faster rate of recombination by the use of series of multiple crosses which would supplement speedy recombination and also break genetic barriers if present.

Frey (1975) recommended the use of diallel selective mating system in self-pollinated crops. Consequent upon based on the present study out of 23 parents involving 20 newly developed lines and three cultivars , only 10 line could be used under such system for their further utilization in breeding purposes.

The sca effects normally do not contribute much in the improvement of self-pollinated crops except where the possibility for the commercial exploitation of heterosis exists. Breeder's interest in self-pollinating crops , therefore, vests in obtaining transgressive segregants through crosses in order to produce homozygous lines, Jinks and Jones (1958) emphasized that the superiority of the mean of the hybrids might not indicate their ability to produce transgressive segregants due to non-fixable portion. In segregating generations, there fore, sca would be important in autogamous crop like Indian mustard.

A critical observation of the results with respect to sca showed that none of the crosses exhibited consistently high sca effects for all the characters (Table 7). It was observed that most of the crosses which did well in F_1 failed to do so in segregating generations. The cause of this difference may be attributed to the existance of large amount of non-allelic interactions operating in the expression of the characters.

In order to select out best specific combiners which may result in desirable segregarts in segregating generations, it becomes necessary to select such derivatives as are desirable from F_1 to F_2 generation. The cross combinations exhibiting significant and desirable sca effects common in both the generations were RK 8604 x Mathura Rai for days to flowering; RK 9002 x Vaibhav and RK 8902 x Mathura Rai for days to reproductive phase; RK 918506 x Laha 101 and RK 8601 x Vaibhav for plant height; RK 8902 x Vaibhav for length of main fruiting branch; RK 8901x Mathura Rai for days to maturity; RK 8604 x

Vaibhav for oil content, other disirable and significant specific combiners were RK 8803 x Mathura Rai , RK 8604x Vaibhav, RK 8608 x Laha 101, RK 8605 x Laha 101 for number of secondary branches. Similarly the significant and disirable performance for two physiological characters namely , relative water content and leaf water potential was recorded in the cross combination KRV 47 x Mathura Rai.

For seed yield per plant, two cross combinations,RK 8902 x Mathura Rai and RK 9x Laha 101 exhibited significant and desivable sca effects in both the generations indicating the presence of predominance of additive x additive type of gene interaction for the expression of the character. The crosses RK 8802 x Laha 101, RK 8701x Vaibhav, RK 8601 x Mathura Rai, RK9001 x Laha 101, RK 8803 x Vaibhav, RK 918506 x Mathura Rai, RK 8901 x Mathura Rai, RK 8608 x Laha 101, RK 8903 x Laha 101, RK 14 x Vaibhav, RK 911296 x Vaibhav and RK 8605 x Laha 101 had positive and significant sca effects for grain yield per plant in F_1 but either they had significantly negative or non-significantly positive sca effects on F_2 generation. Similarly, the croses RK 8691 x Vaibhav, RK 8801 x Mathura Rai, RK 8702 x Mathura Rai, KRV 47x Mathura Rai, RK 8803 x Mathura Rai RK 8605 x Vaibhav, RK 8701 x Laha 101, RK 8604 x Vaibhav, RK 9001 x Vaibhav and RK 9002 x Laha 101 revealed significant positive sca effect for grain yield per plant in F_2 generation but either they possessed significantly negative or non-significantly positive effects in F_1 generation reflecting, therefore, the presence of dominance or epistasis or both types of gene action.

A comparison of sca effects of the crosses with gca effects of the parents involved in the best 14 crosses in F_1 and 12 crosses in F_2 for grain yield per plant revealed that all these crosses had high (significant positive) x high (significant positive) or high x low (non significant-positive or significant negative) or low x low general combiners. Therefore, it could obviously be inferred that a good cross combination is not always the result of high x high or high x low general combiners but may also occur due to low x low general combiners. Choudhary (1974) recorded crosses with high sca effect due to low x low general combiners for some characters including kernel yield in barley . Hayes (1940) and Gowen (1943), however, concluded that low x low combiners, yielded distinctly less than high x low and high x high combiners. The manifestation of high sca effects in the crosses is the result of concentration of favourable genes and their interactions contributed by parents as high or average general combiners (Labana *et al* 1978b).

The high x high and high x average (desirable but not significant) combinations of crosses obtained in the present study could be utilized for the

production of some desirable segregants by adopting biparental progeny selection (Andrus, 1963) on the model suggested by Comstock and Robinson (1948) of Design III. Singh (1972) advocated intermating among select in biparental fashion in early generations and then bulking of the best families to produce a phenotypically uniform but genetically buffered variety in *B. juncea.*

Four hybrid combinations namely, RK 8802 x Laha 101, RK 8701 x Vaibhav, RK9002 x Laha 101 and RK 9 x Laha 101 in F_1 and one cross combiantion viz., RK 8702 x Mathura in F_2 revealed significant and desirable sca effects for seed yield per plant. These crosses also exhibited higher *per se* performance as compared to population mean for yield per plant. These were placed in the first category where both the parents had significant and desirable gca effects for seed yield indicating the presence of additive, digenic (additive x additive), additive epistasis and/or higher order of interaction. The desirable estimates of these cross combinations were due to the involvement of 3-4 attributes directly related to grain productivity.

On the other hand, nine combinations in F_1 namely, RK 8803 x Vaibhav, RK 918506 x Mathura Rai, RK 8901 x Mathura Rai, RK 8608 x Laha 101, RK 8902 x Mathura Rai, RK 8903 x Laha 101, RK 14 x Vaibhav, RK 911296 x Vaibhav and RK 8605 x Laha 101 and seven combinations in F_2 viz., RK 8801 x Mathura Rai, KRV 47 x Mathura Rai, RK 8902 x Mathura Rai, RK 8803 x Mathura Rai, RK 8701 x Laha 101, RK 8604 x Vaibhav and RK 9001 x Vaibhav involved one parent with desirable and significant gca effects and other with poor or negative gca effect, all of them were placed in the second category i.e. high x low. These combinations having significant desirable and high sca effects alongwith better *per se* performance with one good other poor general combiners, are indicative of the presence of additive, dominance and epistasis nature of gene effects. Such specific combiners could produce desirable transgressive segregants as reported by Jensen (1970) Redden and Jenson (1974) in self-pollinated crop plants. The desirable segregants giving rise to new population may be obtained of the additive genetic effects present in good combiners and complementary epistasis effects present in the croses act in complementary fashion to maximise desirable plant attributes which can be exploited for further breeding purposes. The *inter se* crossing of these crosses in all possible combinations for multiple parents input in a central gene pool would be helpful in fastering the recombinations by breaking the genetic blocks (Jensen, 1970).

One hybrid in F_1, RK 8601 x Mathura Rai and four cross combinations in F_2, RK 8601 x Vaibhav, RK 9 x Laha 101, RK 8605 x Vaibhav and RK 9002 x Laha 101 revealed significant and desirable sca effects where both the parents

involved in these combinations expressed as low general combiners and all of them were placed in third category namely, low x low. Such crosss combinations were due to non-additive gene effects and as such these could not be exploited in self- pollinated crops such as Indian mustard. Here it is worth mentioning that the findings of Pederson (1974), Boss (1977) and Sneep (1977) were not in agreement with the contension of Hanson (1969), Jensen (1970) and Redden and Jensen (1974) that intermating in F_2 might result in remarkable improvement in raising the productivity with increased in number of plants with the desirable genotypes.

HETEROSIS AND INBREEDING DEPRESSION IN INDIAN MUSTARD:

Heterosis refers to the developmental stimulation resulting by whatever mechanism from the union of different gametes while hybrid vigour denotes the manifest effect of heterosis. In general term, heterosis refers to the increased vigour of F_1 over the mean of the parents or even over the better parent or economic pare (best cultivar) and it may not be due to any single genetic cause. Powers (1945) and Hayes (1946) considered that heterosis and dominance were different degree of expression of the same physiological genetic phenomenon.

According to Griffing and Lindstorm (1954) and Paterniani and Lonnquist (1963), the experssion of heterosis was due to accumulation of desirable genes in a hybrid plant through the crossing of parents in their genetic make up and it was very often been related to the magnitude of genetic diversity. Robinson (1963) and Moll *et. al.* (1964) were of the view that heterosis was mostly dependent on genetic diversity presented in the parental stock.

Yield is the interaction of many direct and indirect component traits. It may, thus, be intersting to discuss the results obtained in the light of recent concept of genetic basis of yield. Grafius (1959) and Whitehouse *et. al.* (1958) have suggested that there may not be any gene system for yield *per se* which is largely an artefact. Several investigators (Keeble and Pellow, 1910; Grafius 1956 and 1959; Williams and Gribert, 1960; Durrant and Adams, 1963; Coyne, 1965) concluded that the genetic basis of heterosis for a complex trait like yield could be explained by the multiplicative interaction on the phenotypic level for component traits.

The considerable amount of significant heterosis over economic parent (best cultivar) was observed for all the 13 characters. However, in the parent study, none of the hybrids exhibited significant heterosis for all the characters. The heterosis for seed yield per plant ranged from 18.03 per cent to 237.56 per cent. The maximum heterosis exhibited by the KRV 47 x Laha 101 followed by

201.09 per cent in hybrid RK 8608 x Mathura Rai, other nine heterotic crosses which revealed more than 100 per cent increased in grain yield, in order of merit, were RK 8604 x Vaibhav, RK 8601 x Mathura Rai, RK 8801 x Mathura Rai, RK 8602 x Mathura Rai, RK 8601 x Laha 101, RK 8605 x Laha 101, KRV 47 x Mathura Rai, RK 14 x Mathura Rai and RK 8608 x Vaibhav. These crosses also showed desirable amount of heterosis for days to flowering, days to reproductive phase, number of primary and secondary branches per plant (except RK 8605 x Laha 101), plant height (dwarf) and days to maturity. These characters are the important yield components related directly or indirectly to productivity. The preponderance of dominance in the magnitude of over dominance in these traits could be the reason for maximum heterosis for yield per plant. Grafius (1950) suggested that there could not be separate gene system for yield, as the yield is an end product of multiplicative interaction between different components. This would suggest that heterosis for yield should be through heterosis for individual yield components or alternatively due to multiplicative factors, prevailing partial dominance of component characters. Thus it is advantageous to know the relationship beteween heterosis for yield components. Similar findings were reported by Singh (1973), Singh *et al.* (1975), Banga and Labana (1984), Dhillon (1990) and Hirve and Tiwari (1991).

In Indian mustard, seed production can be made feasible by the use of induced male sterilitity, self incompatibility (Singh *et. al.* 1959, 1961) and advance stigma (Singh 1959; Asthana and Singh 1964, 1973) or other systems of which ensure hybrid seed production. The hybrids namely, RK 918506 x Laha 101, RK 8602 x Vaibhav, RK 8602 x Mathura Rai, RK 8604 x Mathura Rai, RK 8601 x Mathura Rai, RK 8601 x Laha 101, RK 8902 x Mathura Rai, RK 8803 x Vaibhav, RK 8604 x Vaibhav, RK 9001 x Laha 101, RK 8803 x Mathura Rai and RK 9 x Vaibhav manifested heterostic response more than 20 per cent for oil content having range of 28.49 to 20.06 per cent. Common hybrids for both seed yield and oil yield were RK 8602 x Mathura Rai and RK 8601 x Laha 101 possessing heterotic response of 155.84 and 148.87 per cent for seed yield; 25.07 and 24.10 per cent for oil content, respectively and were giving less inbreeding depression as compared to rest of the hybrids. These crosses may be exploited further for the development of higher oil yielding genotypes in Indian mustard.

Heterosis being [$\overline{F}_1$-$\overline{P}$] can be more or less dependent on the mean of the parent ($\overline{P}$). Obviously there is every possibility of getting a cross with higher *per se* performance but with low heterosis. In the present study, few such crosses have been observed. It indicated that choice of best cross combinations on the basis of high heterosis would not necessarily be the one which could give highest

per se performance being an estimate the former should be given performance while making the selection of crosses combination.

There is no direct association apparent between combining ability of the parents involved in ten cross and the heterotic response. A combinations of good general combiners did not ensure the best specific cross. For instance, low x low and high x low general combiners in the cross RK 918506 x Laha 101 for oil content and RK 8604 x Mathura Rai for seed yield per plant were the crosses which showed maximum heterosis suggesting thereby non-additive type of gene action. Choudhary (1974) in Barley, Chauhan (1976) and Singh *et al.* (1983) in Indian mustard recorded crosses with low x low general combiners with high heterosis. Chauhan (1976) also reported no correlation between good general combiners and heterotic response in Indian mustard.

Among all the heterotic crosses for oil content over better cultivar, hybrids RK 9 x Vaibhav, RK 8601 x Mathura Rai, RK 8803 x Vaibhav, K 8803 x Mathura Rai, RK 8604 x Mathura Rai, RK 9001 x Laha 101 revealed better performance in F_2 generation too reflecting less inbreeding deprassion (below 15%) indicated the role of fixable gene effects. Such crosses may be sustained by appropriate selection procedure such as pedigree method for development of high oil yielding varieties. On the other hand crosses, KRV 47 x Laha101, RK 8608 x Mathura Rai, RK 8604 x Vaibhav, RK 8801 x Mathura Rai and RK 8602 x Mathura Rai for seed yield per plant revealed significant positive heterosis accompanied by high degree of inbreeding depression (greater than 100%) in F_2 generation indicating there by the role of non-additive gene action. Similar findings were reported by Singh (1991) in Indian mustard. These crosses could be exploited in hybrid breeding programme as to develop hybrid variety for commercial cultivation. However, commercial exploitation of hybrid vigour has its own practical difficulty as such large scale hybrid seed production becomes difficult due to non- availability of suitable male sterile lines.

Generally, there was a clear relationship between heterotic response and inbreeding depression. The maximum inbreeding depression of seed yield per plant was 153.25 per cent in cross KRV 47 x Laha 101 followed by 128.85 per cent in cross RK 8608 x Mathura Rai, and 128.37 per cent in cross RK 8801 x Mathura Rai. Similar to yield per plant, the other characters also showed high amount of inbreeding depression.

SELECTION PARAMETERS IN INDIAN MUSTARD:-

Direct Selection Parameters:-

The heritability is one of the most important direct selection parameters for the breeders because it indicates the extent to which the improvement of a population is possible through selection (Robinson, 1949). It is the measure of genetic relationship between parent and progeny and has widely been used in determining the degree to which a character may be transmitted from parent to the offsping. It also indicates the relative importance of heredity and environment in the expression of characters. High heritability alone is not enough for making selection in advanced generation unless it is accompanied by substantial amount of genetic advance. The heritability in combination with selection response and amount of variability present in the population, influences the gains to be achieved from the selection. Therefore, genetic advance is yet another important direct selection parameter which is not independent and represents the expectation of genetic gain under selection. It has an added advantage over heritability as a guiding factor to breeders in selection programmes where the improvement of character is desired through segregating generations.

In order to streamline the coherent selection breeding programme, Johnson *et al.* (1955) pointed out that genetic gain should be considered alongwith heritability, since the estimates of heritability alone would not be of practical importance in selection based on phenotypic appearance.

It was observed in the present study that the magnitude of heritability estimates was comparable at F_1 and F_2 levels for all the characters except days to reproductive phase, number of primary branches, number of secondary branches, number of siliquae on main fruiting branch, relative water content, leaf water potential, oil content and yield per plant where there was deviation in magnitude from F_1 to F_2 generations (Table 9) Hanson (1963), while reviewing the importance of heritability in plants pointed out the parameter was influenced by method of estimating, generation of hybrids, experimental sample employed and environmens.

The heritability estimate for number of primary branches pooled over environments was low in F_1 but moderate value was in F_2 generation. This was expected because the major portion of gene action controlling the character was non- additive in nature. Contrary to there findings, Rao (1977) and Wan and Hu (1983) observed high heritability values for number of primary branches. The genetic advance in per cent of mean was low, concording with the earlier results of Chauhan and Singh (1973).

Medium heritability in F_1 and low heritability in F_2 was observed for oil content. Grami and Steffan-sson (1977), Wahhab and Bechyne (1977), Pal *et. al.* (1983) and Podhllzina and Shopla (1989) were reported low heritability, whereas, Asthana *et.al.* (1979), Gupta *et. al.* (1985), Jindal and Labana (1985) and Hu (1985) were reported high heritability while the genetic advance in per cent of mean was low in both F_1 and F_2. Other characters viz., erucic acid, oil content, relative water content, days to maturity, number of siliquae on main fruiting branch and days to reproductive phase exhibited low values of genetic gain. The expected genetic advance in per cent of mean was also low for these characters in both the generations. This might largely be attributed to the fact that these characters are governed by non-additive type of gene action which includes the components of dominance and epistasis (Liang and Walter, 1968). Low estimates of heritability were reported by Singh et. al. (1970 b) Singh *et.al.* (1971), Singh (1972), Thurling (1974), Badwal and Labana (1988), Kumar *et. al,* (1988) for grain yield per plant; Singh *et. al.* (1970 a, b), Singh *et. al.* (1972) and Singh (1973) for number of secondary branches; and Singh and Singh (1972) for length of main fruiting branch. Low genetic advance for oil content was also reported by Asthana *et.al.* (1979). Many workers have remarked that heritability of yield is erratic. The findings suggested that total variability that existed for grain and other components were also attributed by environmental factors.

The estimates of heritability pooled over two environments for eucic acid was high and associated with low genetic gain in both the generation. Podhllzina and Shopla (1989) reported low heritability values for this trait. Significant genetic gain for number of secondary branches provided good scope of further improvement by selection in advanced generations and if subjected to a selection scheme simed at exploiting additive (fixable) genetic variance, isolation of improved type for this could be made feasible.

Nevertheless the two physiological characters exhibited moderate to low heritability values associated with moderate magnitude of genetic advance in both the generations. Obviously, it could be noted from such findings that variation in these physiological characters had a significant genetic component and that their measurement is rapid, non-destructive and could be performed at an early stage of growth. Hence their use as selection criteria for heat tolerance would be affective.

INDIRECT SELECTION PARAMETERS:

A knowledge on nature and magnitude of genetic association components of economic worth can help in improveing the efficiency of selection by making possible use of suitable combinations of characters for such selection. Adams (1967) pointed out that sicne yield components and other plant characteristics are

determined at different stages in the ontogeny of the plant, they are affected differentially by environmental factors. Compensation between yield components may lead to varation in correlation pattern and, therefore, he stressed the need for contenial investigation of inter-relationship between yield components.

Johnson *et al.* (1975) emphasized the importance of genotype-environment interactions and their contribution to "genetic slipage" in the selection of complex characters. Thus, studies under different environments might give a clear and reliable picture of association which can effectively be utilized for selecting yield components. Dewey and Lu (1959) emphasized to recognize the nature of population under consideration as the magnitude of correlation coefficient could be included by choice of individuals upon which the observations are made.

Keeping these considerations in view, an attempt was made to study the correlation between yield and its components using F_1 (heterozygous-homogeneous) and F_2 (heterozygous-heterogeneous) population separately under different environmental conditions for 13 characters (Table 10a/10b/10c). Correlation studies were also carried out for two physiological characters along with these 11 characters for F_1 and F_2 population in both the environments (Table 10a / 10b and 10c). Excepting a few cases, the genotypic correlation coefficients were higher than the values of corresponding phenotype correlation coefficients as also observed by Gupta (1972). Katiyar *et al.* (1976) and Sudhakar *et al.* (1979). It indicated that there was strong positive inherent relationship between these estimates.

Grain yield per plant was found to exhibit significant and positive correlation with number of primary branches, number of secondary branches, number of siliquae on main fruiting branch, days to maturity and oil content at phenotypic level and the same magnitude but-varied values at genotype level in the all the population. These findings concorded with the earlier results of Rawat and Anand (1977), Paul *et al.* (1978), Sudhakar *et al.* (1979), Thakral (1982) and Yadav (1982-83) for primary branches; Paul *et al.* (1978), Sudhakar *et al.* (1979), Labana *et al.* (1980), Thakral (1982) and Yadav (1982-83) for number of secondary branches. Paul *et al.* (1978), Labana *et al.* (1979), Yadav (1982), Wan and Hu (1983), Yadav *et al.* (1983) and Richards and Thurling (1979b) for number of siliquae per plant, Bichards and Thurling (1987b) for oil content.

In both the populations (F_1 and F_2), days to maturity exhibited positive and significant correlation with yield per plant. It was expected because late flowering plants get more period for vegetative development. Such findings were reported by Singh *et al.* (1969) for number of primary and secondary branches. Oil content has positive phenotypic association with days to flowering in both the

generations. Rawat and Anand (1977) confirmed the existence of such a relationship between oil per cent and days to flowering. However, days to flowering revealed negative significant association with given yield per plant in F_1 and F_2 generations. It could be inferred that earliness favoured grain yield but exerted negative effects on other developmental attributes of yield. Therefore limited improvement seems to be feasible by selection for earliness, unless some compromise is worked out between favourable and unfavourable associations.

In both the generations (F_1 and F_2), number of primary branches revealed significant and positive association with number of secondary branches and number of siliquae on main fruiting branch. Association of primary branches has been reported by earlier workers (Quadri *et al.* 1966, Shivahare 1975). Primary branches exhibited strong relationship with number of siliquae on main fruiting branch in F_1 and F_2 populations. It indicates that an increase in number of primary branches increase the number of secondary branches and consequently, the grain yield of the cultivar. Obviously, therefore, substantial yield improvements could be achieved if selection was practised for number of primary and secondary branches in early segregating generations.

Number of siliquae on main fruiting branches exhibited positive and significant associations with days to reproductive phase, numer of primary branches, number of secondary branches, height of plant, length of main fruiting branch and days to maturity. Varshney and Singh (1983) reported that the increase in number of siliquae on main fruiting branch per plant improved grain yield per plant. The negative and significant association of oil content with number of siliquae on main fruiting branch confirmed the earlier findings of Agrawal and Rai (1973).

Oil content has a positive and significant phenotypic correlation with days to maturity and days to reproductive phase (grain filling period) in both the generations (F_1 and F_2). Such a relationships were desirable for higher oil content as reported by cereal breeders in maize. Negative association of oil content with plant-height and number of siliquae on main fruiting branch revealed that an improvement in oil content is possible only by decrease in both these attributes. But due to significant and positive association of oil content with leaf water potential it would be imperative to take leaf water potential into account in a selection programme. However in doing so, a balance has to be maintained between these attributes due to unfavourable correlation. Joshi and Dhawan (1966), however advocated that if the adverse associations were due to linkage, they could be made to breaking in the segregating generations and intermating between desirable individuals could be helpful tool in breaking tight linkages.

A significant and positive association existed between relative water content and leaf water potential indicating, thereby, that an increase in leaf water potential improved the water retaining capacity of the genotype. Such a relationship could be regarded as a heat tolerance attribute. Barrs (1968) described significant-differences among species in the relationship of relative water content and leaf water potential and emphasized that both were important measures of plant water deficit under high temperature. However, none of these attributes were observed to exhibit any significant correlation with yield or any of its components reflecting that yield and heat resistance tolerance are controlled by separate genetic entities (Blum, 1974). It was stressed by Blun (1973) that terminal heat stress reduced the grain yield through its effect on individual components, different components being affected according to the timing and magnitude of stress. However, since plant development sequences are correlated component interaction might compensate for increase in some components while reduction in other under the effect of stress.

Days to reproductive phase showed a significant negative association with leaf water potential. It was expected because lower number of days for reproduction enables the genotype to fill grain quickly and thus increase pressure potential for faster role of grain filling. Miskin *et al.* (1972) reported that reproductive phase did not influence the rate of photosynthesis in barley genotypes. If such a situation prevails in *Brassica juncea,* then the possibility of altering heat tolerance without altering the rate of photosynthesis, by selecting varieties with shorter days and consequently greater heat tolerance does exist. Dobrenz *et al*. (1969) studied reproductive phase and its relationship to water use efficiency in Blue pains grass and obtained a non-significant association between these two traits. However, heat tolerant genotypes had shorter reproductive phase than heat susceptible ones.

It can, therefore, be concluded from correlation studies that the most efficient index of selection in *Brassica juncea* for yield under heat stressed environments would need to be based on yield together with developmental traits that correlate well with heat tolerance. Gupta *et al.* (1998) and many others in wheat reported that development traits like early growth vigour, days to grain filling period, days to maturity, senescence of leaf plant height, root development etc. were the traits responsible both for initial as well as terminal heat tolerance, the former is related to germination ability and later is responsible for late planting and both are essential in the development of heat tolerant genotype in *Brassica juncea.*

PATH COEFFICIENT ANALYSIS IN INDIAN MUSTARD

Path coefficient analysis measures the direct influence of one variable upon another and permits the partitioning of correlation coefficient into direct and indirect effects. The use of this method requires a cause and effect relationship among variables (Dewey and Lu, 1959). Path coefficient analysis developed by Wright (1921) has been successfully used by many workers in different crops. It is the partitioning of correlation coefficient into direct and indirect effects and provides an efficient means of critical examination of specific force to produce a given correlation and measures casual factors. Correlation coefficient some times may not give true picture under complex conditions but path coefficient analysis provides a mean of measuring the direct effect as well as indirect effect *via* other variable on the product.

In the present investigation oil yield was found to have positive and significant association with days to reproductive phase at phenotypic level in both the F_1 and F_2 generations. This association as revealed by path analysis was mainly due to the direct positive effect of this character on oil yield. All the remaining characters showed negligible indirect effects except height of plant and length of main fruiting branch in F_1 (negative) and days to flowering and days to maturity in F_2 (negative).

Genetic correlation of oil yield with days to flowering was negative. This negative association as revealed by path analysis was due to negative direct effect of this trait and also negative indirect effects of length of main fruiting branchs, days to maturity and erucic acid and other characters on oil yield. Other character viz, number of siliquae on main fruiting branch, days to maturity and relative water content had negative indirect effect but their magnitude were low.

Number of primary branches per plant was negatively correlated in both F_1 and F_2 generations with oil yield. Path analysis revealed the direct effect of this trait was negative in both the generations. The indirect effects *via* erucic acid, days to maturity and length of main fruiting branch were negative but via. Length of fruiting branch, it was positive in each generation and number of secondary branches in F_2 only.

The association between secondary branches per plant and oil yield was positive and significant. On partitioning of it through path coefficient analysis, it revealed that the direct effect of this character on seed yield was negative in F_1 and positive in F_2 population. The indirect effect *via* number of primary branches per plant and height of plant in F_1 and F_2 generations was negative and positive, respectfully. Thus due to maternal correlation of these effects, the magnitude of

genetic association between number of secondary branches and oil content became high.

Days to reproductive phase, days to maturity and seed yield per plant were found to be positively correlated with oil yield. Further, partitioning it into direct and indirect effects, it revealed that these associations had positive direct effect on oil yield through these traits. Days to maturity (positive) and number of primary branches per plant (negative) had indirect effect on oil yield *via* length of main fruiting branch. These results suggested that correlation coefficient indicated true picture regarding the situation of components affecting oil yield.

Positive and significant association was recorded in F_1 and F_2 population between oil yield and seed yield. On partitioning of this through path analysis, it revealed that direct effect of this trait was positive in both the generations *via* positive direct effect of days to reproductive phase and negative indirect effect of days to flowering on oil yield in each generation.

The direct effects of leaf water potential, erucic acid, number of siliquae on main fruiting branch and height of plant in oil yield were negative. However, the genetic correlation between oil content and erucic acid content was also negative in both $F_1$and F_2 generations. These negative associations in both the generations were due to negative indirect effect of number of traits related components as well as developmental attributes.

Thus, on the basis of results of path coefficient analysis, it was concluded that days to reproductive phase, number of secondary branches, days to maturity and seed yield per plant are the most important oil yield contributing characters. Therefore while practising selection for higher oil content yield due emphasis should be given to these characters during the selection process. These findings are in accordance with results already obtained by several workers. For example the positive direct effect of number of secondary branches on seed yield were also reported by Shivhare (1975), Tak (1976), Rawat and Anand (1977), Kumar and Yadav (1978), Yadav(1982), Srivastava *et al.* (1983), Singh and Chaudhary (1983) and Kumar *et al.* (1984).

The residual effect in the present study indicated that there was no major yield governing traits that might influence the yield, had been left out and that all the important traits influencing oil yield had been included in the present investigation.

IMPLICATION ON BREEDING METHODOLOGY IN INDIAN MUSTARD :

It is pertinent to suggest suitable breeding methodologies on the basis of genetic informations obtained from the study on Indian mustard for bringing the improvement in seed yield, oil content and its components.

The genetical study revealed importance of both the additive and non-additive genetic variances for all the 13 characters related to developmental, physiological and quality traits in Indian mustard but predominance was recorded for non-additive genetic variance for all the characters except erucic acid. Under such situation, the improvement could be based on the simultaneous exploitation of both the genetic components. The conventional breeding methods like pedigree, bulk and back cross etc. exploit that portion of genetic variability which is due to additive or additive x additive gene effects. For effective utilization of both the additive and non-additive genetic variances, population breeding technique and particularly more of the non-additive effects, the recurrent selection scheme with suitable modification like selective diallel or triple test cross or Bip's mating would be more effective to release hidden genetic variability for further improving the material.

The occurrence of predominance of non-additive genetic variances for 12 out of 13 attributes will necessiate to the maintenance of heterozygosity in the population. As this type of genetic variability is non-fixable, hybrid breeding approach is likely to hasten the rate of genetic improvement. Heterosis breeding as a mean of achieving better productivity is a well known fact under such situations. Heterotic values were recorded more then 200 per cent in two crosses for seed yield and more than 20 per cent for oil content were recorded in 12 crosses, reflecting hybrid vigour could be exploited through the development of hybrid varieties.

A question arises, whether elite strains / varieties as investigated in the present study could provide the suitable base material for development of more productive and suitable cultivars and also as a broad base population with wider adaptability. The parents could be classified as early maturing and late maturing and it was possible to develop two different early and late maturing populations among these parents. Based on gca performance, parents, RK 8702, RK 8901, RK 14, RK 8701, RK 8601, RK 8605, RK 8608, RK 8801, RK 9001 and RK 911296 for number of attributes related to seed yield coupled with oil content and possessing desirable amount of terminal heat tolerance were most desirable combiners. These lines were early to medium maturing. Among these the late group was found adapted particularly for stress conditions and possessed the desirable mean for grain yield, oil content and other attributes. A population made

out from these parents might proved quite amenable to disruptive selection in respect of flowering and maturity. This would ensure high gca and high mean in the population and would help in generating a range of combination, more varied than the existing ones.

The simultaneous improvement in seed yield and oil content with their component, developmental and quality traits could be achieved through multiple cross followed by recurrent and modified recurrent selection procedures. Such type of breeding approaches release hidden genetic variability, break of undesirable linkages and produce desirable genetic recombinants. Matzinger *et al.* (1977) pointed out the recurrent selection with random mating appeared to have tremendous potential for improvement in the population of self-fertilizing species. On the basis of present findings, multiple parents input in gene pool would be made among the cross combinations possessing high sca effect, namely RK 8604 x Mathura Rai, RK 9002 x Vaibhav, RK 8902 x Mathura Rai, RK 918506x Laha 101, RK 8601 x Vaibhav, RK 8902 x Vaibhav, RK 9001 x Mathura Rai, RK 8901 x Mathura Rai, RK 8902 x Mathura Rai, RK 9 x Laha 101 and RK 8604 x Vaibhav for releasing latent variability which might be useful for high grain yield and oil content with other traits related to productivity. The segregating population should also be subjected for vigorous selection in isolating desirable genotypes for stress agro-situations.

Characters like days to flowering, plant height, number of secondary branches, days to maturity, erucic acid and days to reproductive phase could be given greater emphasis in selection breeding programme as they exhibited considerable amount of heretability and genetic gain. They also manitested desired level of correlated response and direct effects with grain yield and oil content. Grafius *et al.* (1976) and Knott (1979) have concluded that components traits are not passive participants in the determination of grain yield but on the contrary exert active influence on yield through the source-sink transport relationships. Hence they suggested component complementation as procedure for obtaining higher yield.

CHAPTER 6

SUMMARY

SUMMARY

The present investigation on *"Genetical studies for agronomic and quality traits in Indian mustard [Brassica juncea (L.) Czern and Coss]"* was carried out to study the combining ability variances and genotype x environment interactions, heterosis and inbreeding depression, heritability and genetic advance, correlations alongwith path co-efficient analysis in F_1 and F_2 generations possessing 60 straight crosses developed through line x tester mating design.

The base material for the present study comprised 23 parents (20 Lines and 3 testers), 60 F_1s and 60 F_2s. The experiment was laid out during *Rabi* 1994-95 in a Randomised Complete Block Design with three replications at two different agro-environments (normal and late sowings) of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur- 208 002.

The observations were recorded for days to flowering, days to reproductive phase, number of primary branches, number of secondary branches, height of plant, length of main fruiting branch, number of siliquae on main fruiting branch and days to maturity. In addition to these, observations were also recorded on relative water content, leaf water potential yield per plant, oil content and erucic acid in both the generations (F_1 and F_2) and in both the environments. The data were subjected to different biometrical computations as given in methods and material. The findings obtained on different aspects for 13 different attributes are summarized as under:

Analysis of variance for the experiment revealed highly significant differences among the treatments for all the 13 characters in both the F_1 and F_2 generations as well as in both the environments. Analysis of pooled data further exhibited significant differences among the crosses for all the 13 attributes in both the generations and environments. Interactions between crosses and environments were also highly significant. The interaction component, were highest for plant height and days to maturity followed by length of main fruiting branch and yield per plant.

The combining ability analysis indicated highly significant differences among females x males for all the 13 characters in both the generations and environments. Significant differences were also observed in males and females for some characters at different environments. Pooled analysis for combining ability showed significant differences in environments, females, males, females x males and all the possible interactions between them in number of attributes.

The components of variance revealed the preponderance of sca variance for all the traits in both environments and in both F_1 and F_2 generations except erucic acid in both the generations as well as in both the environments. A consideration of components of variance on pooled basis also indicated similar findings. Nevertheless, the esimates of $\hat{\sigma}^2_D$ were higher than $\hat{\sigma}^2_A$ for all the traits in both generations and environments except erucic acid in F_1 and F_2 generations and in both environments for which $\hat{\sigma}^2_A$ was greater in magnitude.

The estimates of average degree of dominance exhibited over dominance for all the traits in both the F_1 and F_2 generations and both environments except erucic acid where partial dominance was recorded. The average degree of dominance pooled over locations observed in the range of over dominance for all the traits in both the generations except erucic acid in which partial dominance was observed in both the generations.

None of the parent was found to be a good general combiner for all the 13 characters. The parents which exhibited significant and desirable gca effects in both the generations pooled over environment were RK 8605 and RK 8602 for early flowering, RK 9001, RK 911296, RK 14 and RK 8608 for days to reproductive phase; RK 9001, RK 911296, RK 8608 and RK 8902 for number of primary branches, RK 14 for number of secondary branches, RK 8601, RK8605, RK 9001 and RK 8702 for plant height, RK 8605, RK8901, RK 8701, and RK 8702 for length of main fruiting branch, RK 8901, and RK 8702 for number of siliquae on main fruiting branch, KRV 47 for days to maturity, RK 8702, RK 8601, RK 8701, RK 8602 and RK 8604 for relative water content, RK 8601, RK 8903, RK8702, RK 9001 and Mathura Rai for leaf water potential, RK 8702, RK 911296, RK 8802 and RK 8701 for yield per plant, RK 8901, RK 9001, RK 8605 and RK 8604 for oil content and RK 8801, RK 8903 and RK 8901 for eurcic acid.

Parents RK 8702, RK 8901, RK 14, 8701, RK 8601, RK 8605, RK 8608, RK 8801, RK 9001 and RK 911296 were desirable general combiners for three or more character related yield attributes for terminal heat tolerance.

The study of sca effects revealed that none of the crosses was found good specific combiner for all the attributes in both the generations. Most of the crosses which did well in F_1 failed to do so in F_2. The cross combinations exhibiting significant and desirable sca effects common in both the generations were RK 8604 x Mathura Rai for days to flowering, RK 9002 x Vaibhav and RK 8902 x Mathura Rai for days to reproductive phase, RK918506 x Laha 101 and RK 8601 x Vaibhav for plant height, RK 8902 x Vaibhav for length of main fruiting branch, RK 8901 x Mathura Rai for days to maturity, RK 8902 x Mathura Rai and RK 9 x Laha 101 for yield per plant and RK 8604 x Vaibhav for oil content.

Other desirable cross combinations were RK 8803 x Mathura Rai, RK 8604 x Vaibhav, RK 8608 x Laha 101 and RK 8605 x Laha 101 for number of secondary branches.

The significant and desirable specific performance for two physiological characters, viz. relative water content and leaf water potential was observed in the cross combination KRV 47 x Mathura Rai.

Majority of the desirable specific combiners were derived either from high x high or high x low or and low x low general combiners in both the F_1 and F_2 generations.

The heterotic crosses exhibiting more than 125 per cent heterosis over better variety for yield per plant were KRV 47 x Laha 101, RK 8608 x Mathura Rai, RK 8602 x Mathura Rai, RK 8601 x Laha 101, RK 8605 x Laha 101 KRV 47 x Mathura Rai and RK 14 x Mathura Rai. For oil content, the heterotic crosses giving more than 20 per cent heterosis over better variety were RK 918506 x Laha 10, RK 8602 x Vaibhav, RK 8602 x Mathura Rai, RK 8604 x Mathura Rai, RK 8601 x Mathura Rai, RK 8601 x Laha 101, RK 8902 x Mathura Rai, RK 8803 x Vaibhav, RK 8604 x Vaibhav, RK 9001 x Laha 101, RK 8803 x Mathura Rai and RK 9 x Vaibhav. The common crosses for these two attributes were RK 8602 x Mathura Rai and RK 8601 x Laha 101 and these also showed less inbreeding depression.

The heritability estimates, in narrow sense pooled over environments for days to flowering, height of plant, days to maturity and erucic acid were high in F_1 and F_2 generations. Medium heritability in both F_1 and F_2 generations was observed for number of secondary branches, length of main fruiting branch and leaf water potential. Moderate values for this parameter were recorded for days to reproductive phase, relative water content and oil content in F_1 while in F_2, number of primary branches and yield per plant exhibited the same response. Other traits either in F_1 or F_2 revealed low estimates of heritability.

Genetic advance in per cent of mean was high for number of secondary branches in F_1, moderate genetic gain was recorded in days to flowering, height of plant, length of main fruiting branch, leaf water potential and yield per plant in both the generations; number of primary and secondary branches in F_2. Low values of genetic gain were exhibited for erucic acid, oil content, relative water content, days to maturity, number of siliquae on main fruiting branch, length of main fruiting branch and days to reproductive phase in both the generations and number of primary branches in F_1.

The significant associations were observed in 36 and 31 cases out of 78 all possible correlations in F_1s and F_2s respectively. Twenty six associations being common in both the generations. The correlation of grain yield with four component traits (number of primary branches, number of secondary branches, length of main fruiting branch and number of siliquae on main fruiting branch) were not strong except in one case (F_1 and F_2) exceeded + 0.35. Associations were significant and in favourable direction between grain yield and number of primary branches and length of main fruiting branch in both the generations and was desirable with number of siliquae on main fruiting branch in F_2 only. Thus, present material is amenable for simultaneous improvement in grain yield and its three direct components. Amongst the four developmental traits (days to flowering, days to reproductive phase, height of plant and days to maturity), grain yield exhibited significant and desirable associations between grain yield and days to flowering and height of plant indicated that it could be possible to breed early flowering recombinants with dwarf type with high grain yield. Among two physiological traits (relative water content and leaf water potential), grain yield was significantly associated with relative water content indicating higher grain yield would be obtained if the water content remained available in the leaf till older stages of development. Among the two quality components (oil content and erucic acid), grain yield was significantly associated with oil content exhibiting higher oil content could be achieved by increasing the production in seed yield. Erucic acid was significantly and negatively associated with oil yield and seed yield in both the generations indicating that low erucic acid content could be obtained by increasing either seed yield or oil content or both, hence erucic acid did not interfere in the productivity.

Genotypic associations of oil yield (oil content x oil yield) with other 12 characters were further partitioned into direct and indirect effects on oil content pooled over environments in both F_1 and F_2 generations. Based on this path coefficient analysis, days to reproductive phase, number of secondary branches, days to maturity and seed yield were the most direct important oil contributing attributes, thus, due weitage should be given to these characters during selection breeding programme.

The implications on breeding methodologies have been discussed for the practical utility in the improvement of Indian mustard. The efficacy of intermating coupled with selection programme have also been discussed in terms of breeding procedures.

CHAPTER 7

BIBLIOGRAPHY

BIBLIOGRAPHY

Abercrombie, M., Hickman, C.J. and Johnson, M.L. (1961). *A Books/ Dictionary of Biology. Penguim Reference Books,* Barnard and Co. Ltd. Aylesbury.

Adams. M. W. (1967). Basis of yield component Composition in crop plants with special reference to field bean. *Phaseolus vulgaris*, *Crop. Sci.,* 7: 505-510.

Abraham, T.P.; Butany, W. T. and Ghosh, K.L.U. (1954). Discriminate function in rice. *Indian, J. Genet.,* **14** : 50-53.

Ahuja, K.L.; Batta, S.K.; Raheja, R.K.; Labana, K.S.; Gupta, M.L. (1989). Oil content and fatty acid composition of promosing Indian *Brassica Campestris* L. (toria) genotypes. *Plant Foods for Human Nutrition,* **39** (2): 155-160.

Agrawal, B.C. and Rai, B. (1973). Component analysis of factors influencing oil production in toria. *Indian J. Genet*, **35 :** 142-146.

Al-Jibouri, M.A, Miller, P.A. and Robinson, H.F. (1958). Genotypic and environmental variances in an upland cotton cross of inter-specific orgin. *Agron J.* **50 :** 633-637.

Allard, R.W. (1950). The analysis fo genetic environmental interaction by means of diallel cross. *Genetics,* **41:** 305-308.

Allard, R.W. and Bradshwa, A.D. (1964).Implications of genotype environment interation in applied plant breeding. *Crop Sci.* 4: 503-508.

Amrithadevarathinan, A., V. Arunachelam and B. R. Murty (1976). A quantitative evaluation of intervariatal hybrids of *Brassica Campestris* L. *Theor. Appl. Genet.,* **48** : 1-8.

Anand, I.J. and Rawat, D.S. (1978). Exploiting cyto plasmic male sterlity from heterosis breeding in ***Brassica Juncea.*** Paper presented as *International Conference on Cytongenetics and Crop Improvement, B.H.U.* Varanasi, India.

Anand, I.J. Rawat, D.S. (1984). Genetic diversity, combining ability and heterosis in Brown mustard. *Indian J. Genet.,* **44** 226-234.

Andrus, C.F. (1963). Plant breeding system. *Euphytica* **12** : 205-228.

Anderson, V.L. and Kempthorne, O. (1954). A model for study of quantitative inheritance. *Genetics,* **39** : 883-898.

*Ashton, T. (1948). Techniques of breeding for drought resistance in crops. *Common W. Bur. Plant Breed. Genet. No.* **14**.

Asthana, A.N. Dubey, S.D.; Tiwari, P.N.; Gambhir, P.M. and Rajan, T.S. (1979). Variability studies and breeding for increased oil content in rapeseed mustard. *Expl. Agric.,* **15**: 65-71.

Asthana, A.N. and Pandey, V.K. (1977). Combining ability and rank correlation in a diallel cross of Indian mustard *(Brassica juncea) Expl. Agric.,* **13** : 71-79.

Asthana, A.N. and Singh C.B. (1964). Advanced Sigma mutant in *Rai (Brasica juncea)* and yellow *sarson (B. Campestris)* Var. Yellow *Sarson. Sci.* and *Cutl.* **30** : 151-152.

Asthana, A.N. and Singh ; C.B. (1973). Hybrid vigour in rai. *Indian J. Gent.,* **33** : 57-63.

Badwal, S.S. and Labana, K.S. (1987). Combining ability seed size, oil and protein content in Indian mustard. *Crop improv.* **14** (1) **:** 10-13.

Badwal, S.S. and Labana, K.S. (1988). Diallel analysis for some metric straits in Indian mustard *Crop improve.,* **14** (2) **:** 191.194.

Badawal, S.S., Singh N., Labana, K.S. and Chaurasia, B.D. (1976). General Vs. specific combining ability in raya *(Brassica juncea L.* Czern and coss**).** *J. Res. Pb. Agric. Univ.* **13** : 319-323.

Banga, S.S. and Labana, K.S. (1984). Heterosis in Indian mustard *[Brassica juncea (L.)* Czern & coss.] *Zeitchriftfuer Pflanzen Zuechtung.,* **92** : (1) 61-70.

Bang, J.K.; Rho, S.P. Kim, S.K. and Lee. J.I. (1986). Path coefficient analysis and correlation coefficient of agronomic characters in mustard *Res. Rept. Rural Development Admin. Karea Republic Crops.* **28** (1) : 194-198.

Bauman, L.F. (1959). Evidence of non-allelic gene interaction in determining yield, ear light and karnal *row* number in corn. *Agron. J.*, **51** 531-534.

Boss I. (1977). More arguments against intermating F_2 plants of self fertilizing crops. *Euphytica* **26**: 33-46.

Burton, J. L. (1948). Combining ability of alfalfa. *Sci. Agri.*, **28** : 97-126.

Behl, R.K.; Chowdhary, B.D.; Singh, R.P. and Singh, D.P. (1992). Marpho physiological determinants of oil yield in *Brassica juncea* under dryland conditions *Indian J. Genet.*, **52** (3): 280-284.

Blum, A. (1974). Genotypic response in sorghum to drought stress. II Leaf-tussue water relations *Crop. Sci.* **14** : 691-692.

Bunson, M. (1980). Heterosis and genetic parameters in winter rape *(Brassica napus). Crucieferae News Letter,* **5** : 13-14.

Burton, G.W. (1959). Breeding methods for pearl millet *(Pennisetum Glaucum)* indicated by genetic variance component studies. *Agron. J.* **51** :479-481.

Chander, J.; Chaudhary, M.S. and Chaudhary, B.D. (1985). Identification of parents for hybridization through combining ability analysis in Indian mustard. *J. Oil seeds res.*, **2** : 191.202.

Chaudhary, B. D. (1974). Extimation of genetic parameters in barley by dillel and its modifications *Unpupl. Ph. D. Thesis HAU, Hissar.*

Chaudhary, R.M. and Sinha, S. K. (1999). Preliminary characterization of some physiologically important mutants in *Brassica juncea* L. coss & czem. Variety RLM 198. *Indian J. Genet.* **59** (2) : 175-191.

Chaudhary, L.B. (1967). Correlation studies in *Brassica juncea. Indian J. Genet.*, **39** : 425-433.

Chaudhary, M.A. Miaha A.J.; Rehman. L. and Rehman, A. (1988). Correlation and path coefficient analysis in 9 important characters in mustard *(Brassica juncea) Bangladesh J. Ag.* B.A.U.

Chaudhary, R.R. and Goswami, G.D. (1991). Genetic variability studies in Indian mustard *(B. Juncea* L. Czern and Coss). *Environment* and *Ecology,* **9** : (4) : 1003-1006.

Chaudhary, S.K. and Sharma, S.K. (1982). Not on the inheritance of some quantitative characters in a cross of Indian mustard. *Indian J. Agri. Sci.,* **52** :23-25.

Chauhan, S.S., Srivastav, R.K., Kumar, K (2000). Heterosis in single and Three-way crosses in Indian mustard. (*Brassica juncea* L. czern & coss. *Indian J. Genet.* **60** (1) : 131-132.

Chauhan, Y.S. (1987). Genetic analysis for yield and its components in Indian mustard. *Indian J. Agric. Sci.* **21** (2): 77-82.

Chauhan, Y.S. and Singh, A.B. (1973). Heritability estimates and gene effects of some agronomic traits on Indian mustard. *(Brassica juncea (L). Czern* and *coss*) *Indian J. Agri. Sci.* **43** : 191-194.

Chauhan, Y.S. and Singh, D. (1979) Genetic architecture of some quantitative characters in Indian mustard. *Indian J. Genet.*,**40:**597-599.

Chauhan, Y.S. and Singh D. (1980). Inheritance of seed weight in Indian mustard. [*B. juncea* (L) *czern* and *coss*]. *Indian J. Genet.*,**40:**597-599.

Cockerham, C.C.(1954). An extension of concept of partitioning hereditary variance for analysis of co-variances among relations when epistasis is present. *Genetics*, **39:**859-882.

Comstock, R.E., H.F. Robinson and C.C. Cockerham (1957). Quantitative Genetics Project report. North Carolina State College, Institute of Statistics. *Mimco Serics., No.*167.

Comstock, V.E, and Moll, R.N. (1963). Genotype environment interactions. *Statistical Genetics* and *Plant Breeding* NAS-NRC, Washington, Publ. **982:** 164-196.

Comstock, R.E. and Robinson, H.F. (1948). The components of genetic variance in population of bi-parental progenies and their use in estimating the average degree of dominance. *Biometrics,* **4:** 254-266.

Comstock, R.E. and Robinson, H.F., (1952). Estimation of average degree of dominance of genes. In *Heterosis* Ed. G.W. Gowen Iowa State College Press Ames. *Iowa*, 494-516.

Comstock, R.E.; Robinson, H.F. and Harney, P.H. (1949). A breeding procedure designed to make maximum use of both general and specific combining ability. *Agron.J.* **41:** 360-367.

Coyne, D.P. (1965). Component interaction in selection to heterosis for plant height in Phaseolus vulgare L. variety cross. *Corp. Sci.* **5 :** 17-18.

Crumpacker, D.W. and Allard, R.W. (1962). A diallel cross analysis for heading date in wheat. *Hilgardia,* **32 :** 375-378.

Darwin, C.C.(1977). The effect of cross and self fertilization in the vegetable kingdom VIII – 482 pp. D. Appleton and Co., London C. F. Breeding Crop plants. H. K. Hayes and R. J. Garber.

Dewey, D. R. and Lu, K. H. (1959). A correlation & Path coefficient analysis of components of crusted wheat grass seed production. *Agron. J.* **51** : 515-518.

Durate, R. and Adoms, M. W. (1963). Component interaction is relation to expression of a complex trait in field bean cross. *Crop. Sci.* **3** : 185-186.

Dhillion, S.S.; Labana, K.S., Singh, Balwant and Ahuja, K.L. (1990). Association analysis in Indian mustard. *J. Res. Punjab Agric. Univ.*, **27:** (3) **:** 385-388.

Dhillion, S.S.; Labana, K.S. and Banga, S.K. (1990). Studies on heterosis and combining ability in Indian mustard. *(B. Juncea L. Czern Coss) J. Res. Punjab Agic. Univ.,* **27:** (1):1-8.

Dickinson, A.G. and Jinks, J.L. (1956). A generalized analysis of diallel cross. *Genetics,* **41:** 65-78.

Diskalov, H. (1963). The problem of nature of heterosis phenomenon. *Zbi bulqwise. Vit,* **7:**13 cc f. *Plant Breed Abst.,* **34:** 167.

Dixit, R.K.; Prasad, K and Srivastava, A.M. (1983). Combining ability for quality character in Indian mustard. *Indian J. Agric. Sci.* **53:** 776-778.

Doloi, P.C. and Rai, B. (1981). In breeding depression in rapeseed *(Yellow sarson). Indian J. Genet.,* **41:** 368-378.

Duhoon, S.S. Chandra S., Basu, A.K. and Makhiya O.P. (1979). Combining ability analysis of yield and other quantitative character in Brassica campestris var. yellow *sarson. Indian J. Agric. Res.* **13:** 7-12.

Durrant, A. (1965). Analysis of reciprocal difference in a diallel crosses *Heredity*, **20**: 573-608.

East, E.M. (1908). Inbreeding in corn. *Cron. Agri. Exp. Sta.* (New Haven) *Rep.*, 1907: 419-428.

Fedever, W.T. and Sprague, G.F. (1947). A comparison in variance component in corn yield traits. I Error : Tester x line components in top cross experiments. *J. Amer. Soc. Agron.* **39** : 453-463.

*Fisher, R.A. (1918). The correlation between relations on the supposition of Mendalian inheritance. *Tans. Roy. Soc.* Edinburgh, **52** : 399-433.

Fisher, R.A. (1936). The use of multiple measurement in texonomic problems *Am. Eugen.* **7** : 179-188.

Fisher, R.A. and Yates, F. (1943). *Statistical Tables for Biological, Agricultural* and *Medical Research.* Ed. Oliver and Boyd., London.

Fisher, R.A.; Immer, F.R. and Teddin, O. (1932). The genetical interpretation of statistics of the degree of the study of quantitative inheritance. *Genetics*, **17**: 107-124.

Frey, K.J. (1975). Breeding concepts and techniques for self-Pollinated crops. *Proc. of Symp. on Intern. Workshop on Grain Legumes*, held at ICRISAT, Hyderabad, pp 257-278.

Frey, K.J. and Horner, T.W. (1957). Heritability in standard unit *Agron. J.* **49** : 59-62.

Gamble, E.E. (1962). Gene effects in corn (Zeamays L.) I-separation and relative importance of gene effects for yield. *Canad. J. PI. Sci.*, **42**: 339-348.

Gardner,C.O. and J.H. Lonnquist (1959) Linkage degree of dominance of genes controlling quantitative characters in maize. *Agron.J.*, **51:** 524-528.

Gardner , C.O. (1963). Estimates of genetic parameters in cross fertilizing plant and their implications in plant breeding. In: *statistical Genetics* and *Plant Breeding*. NAS NRC, 982: 53-94.

Gardner,C.O., Harney, P.H.; Comstock, R.E. and Robinson, H.F. (1953). Dominance of gene controlling quantitative characters in mazie. *Agron J.*, **45** : 186-191.

Galton, F. (1989), *Natural Inheritance Ed.* Mc Millen and Co. London.

Gardener, C. O. and J. H., Lonnquist (1959). Linkage and degree of dominance of genes controlling quantitative characters in waize. *Agron. J.* **51** : 524-528.

Gilbart, N.E.G. (1967). Additive combining ability fitted to plant breeding data *Biometrics* **25** : 45-50.

Gilbert, M. (1958). Diallel cross in plant breeding *Heredity,* **12** : 477-492.

Govil, S.K.; Chaubey, C.N. and Chauhan, Y.S. (1980). Direct relation response in *[B. juncea* (L.) Czern and coss] *Plant sci.*, **12** : 28-29

Govil, S.K.; Chaubey, C.N. and Chauhan, Y.S. (1981). Combining ability studies in Indian mustard *Indian J. agric. Sci.* **51** : 623-626.

Govil (1981). Gene action for oil content in Indian Mustard. *Indian J. Agric. Sci.* **33** : 404-406.

Govil, S.K.; Srivastava, A.N. and Chauhan, Y.S. (1983). Gene action for oil content in Indian mustard. *Indian J. Agric: Sci.,* **33** : 404-406.

Gowen, J. W. (1952). Heterosis, ed. J. W. Gowen. Iowa State College Prss, Ames, Iowa.

Grafius, J. E. (1954). A geometry of plant breeding. *Crop. Sci.* **4** : 241-246.

Grafius, J.E. (1956). Components if yield in oats. A geometric interpretation. *Agron. J.,* **48** : 419-423.

Grafius, J.E.; Roger,L; Thomas and Jone, Bernard (1976). Effect of parental component complementation on yield and component yield in barley. *Rop. Sci.* **16** : 673-677.

Grafius, J.E.(1959). Heterosis in barley. *Agron. J.,* **51 :** 551-554.

Grafius, J.E. (1964). A geometry for plant breeding. *Crop. Sci.,* **4** : 241-246.

Grami, B. and Stefansson, B.R. (1997). Gene action of protein and oil content in summer rape. *Canad. J.Pl. Sci.,* **57** : 625-631.

Griffing, B. and Lindstarm, E. W. (1954). A study of the combining abilities of corn inbreds having varying population of corn Belt and non-corn Belt germplasm. *Agron. J.* **46** : 545-552.

Griffing, B. (1956a). A generalized treatment of the use of diallel cross is quantitative inheritance. *Heredity* **10** : 31-50.

Griffing, B. (1956b). Concept of general and specific combining ability in relation to diallel crossing system. *Aust. J. Biol. Sci.* **9** : 463-493.

Grogan,C.O. and Zuberi, N.S.(1957). A comparative study of top cross tester parents of maize. *Agron. J.* **49** : 68-72.

Gupta, M.L.; Banga, S.K. and Sandhu, G.S. (1983). Heterosis and combining ability in *Brassica compestris* app. Oleifera var *Toria.* National seminar on oil seeds, Haderabad, **54.**

Gupta,M.L.Gupta V.P. and Labana (1987).combining ability of seed yield and its components in Indian mustard. *Crop Improv.,* **14** (2) : 160-164.

Gupta M. L., Labana, K.S. and Badwal, S.S. (1988). Correlation and path of matrix traits contributing towards oil yield of Indian mustard. *P.A.U.* Ludhiana, India **9** (a): 33-37.

Gupta P.R. (1972a) Interrelationship studies among some yield contributing attibutes in rai [*Brassica juncea* (L.) *Czern* and *coss*] *Madras Agric. J.,* **59** (8): 421-425.

Gupta R.R. (1992) Genetic variability and heritability of yield and its comoponents in rai [*Brassica juncea* (L.) Czern & coss] *Madras J. Agric. Res.,* **52**: 642-644.

Gupta S.K. and Labana, K.S. (1988) . Genetic of oil content in seed rape (B. napus). *Cruciferae News Letter,* **13**: 48.

Gupta S.K. and Labana, K.S. (1989a). Genetic variation for Physiological traits in rape seed. *Indian. J. Genet.,* **49** (3): 355-358.

Gupta S.K. and Labana,K.S. (1989b) Genetic variation for some physico-morphological traits in oil seed rape (*Brassica napus*) *Indian J. Genet.,* **49** (3): 365-367.

Hanson, W. D. (1959). The break of initial linkage blocks under selecting mating systems. *Genetics* **44** : 857-868.

Hedge, D.M. and Kiresur, V. (1999), Changing paradigms. The Hindu Survey of Indian Agril. pp 67-72.

Haldane, J.B.S. (1932).The time of action of genes and its bearing on evolutionary problems, *Amer, Net.*, **66** : 232-243.

Hayes, H. K. (1946). American Naturalist. **80** : 430-445.

Hayes, H.K.; Immer, F.R. and Smith, D.C. (1955). *Method of plant Breeding.* Mc. Graw Hill Book Co. Inc., New York.

Hayman, B. I.(1954a). The theory and analysis of diallel cross. *Genetics*, **39** : 789-809.

Hayman, B.I. (1954b). The analysis of variance of diallel tables. *Biometrics,* **10** : 235-244.

Hayman, B.I. (1963). Notes on the diallel cross theory. *Statistical Genetics* and *Plant Breeding* NAS-NRC publ. **11:** 69-82.

Henderson, C.R. (1952). Specific and general combining abilities.352-30 *In: Heterosis,* J.W. Cowen Ed. Iowa State College Press. Ames. *Lowa* PP *522.*

Hirve, C.D. and Tiwari,A.S.(1991). Heterosis and inbreeding depression in Indian mustard, *Indian J. Genet.,* **51** (2): 190-193.

Horner, T.W. (1952). Non-allelic gene interaction and the interpretation of quantitative date. *Ph.D. dissertation,* north Carolina state college, Library,

Hu, Z.L. (1988). A genetic analysis of quantitative character in rapeseed (*Brassica napus* L.) *Cruci ferae Newsletter.* **13:** 58.

Hull, F.H.(1947). Recurrent selection and over dominance pp. 352-370. in *Heterosis* J.W. Gowen, Ed. I*owa* State College Press Ames. I*owa* pp: 552.

Hull, F.H. (1947). Cryptic homozygous lines *J. Amer. Soc. Agron* **39:** 438-439.

Hurd, E.A.(1976). Plant breeding for drought resistance. In: *Water Deficits* and *Plant Growth.* Ed. Koklowski, T.T. Acad Press, N.Y. pp. 317-353.

Jenson, N. F. (1970). A diallel selective mating system for cereal breeding. *Crop. Sci.* **10** : 629-635.

Jinks, J.L. (1954). The analysis of continuous variation in a diallel cross of *Nicotona rustica Verities. Genetics*, **39:** 767-788.

Jinks, J.L. (1955). A survey of genetical basis of heterosis in a variety of a diallel crosses. *Heredity,* **9:** 233-238.

Jindal S.K. and Labana, K.S. (1986). Combining ability in a complete diallel cross of Indian mustard. *Indian J. Agric*., **56** (2) : 75-79.

Johannson, W.L. (1909). *Elements der exakten Erb*lichkeitslehere Gustav Fisher Verlags buchnand lung, Jena.

*Johanson, H.M.; Robinson, H.F. and Comstock, R.E.(1955a). Genetypic and phenotypic correlation in soyabeen and theiir implications in selection. *Agron, J.,* **47** : 427-483.

Jones, D.F. (1924). The origin of flint and dent corn. *J. Heredity* **15** : 415-519.

Jones, D. F. (1939). Continued inbreeding in maize. *Genetics* **24** : 462-473.

Joshi, A. B. and Dhawan, N.L. (1966). Genetic improvement in yield with special reference to self-fertilizing crops. *Indian J. Genet.* **26** (A) : 101-113.

Katiyar, R.P.; Mishra, B. Singh,S.N, adn Chauhan Y.S. (1974). Genetic variability, heretability and genetic advance of yield and its components in Indian mustard. *Indian J. Agric. Sci.* **44** (5) : 291-293.

Katiyar, R. P. and Singh, B. (1976). Interrelationship among yield and its components in Indian mustard. *Indian J. Agric. Sci.* **44** (5) : 287-289.

Kebble, f. and Pellow, C. (1910). The mode of inheritance of stature and time of flowering in peas (*Pisum sativum*) *Indian J. Genet.* **1** : 47-56.

Keller, K.R. (1949). A comparison involving the number of, and relationship between testers in evaluating inbred lines of maize. *Agron, j.,* **4** : 323-331.

Kempthorne, D. (1955). The Correlation between relation and inbred populations, *Genetics*, **40** : 681-691.

Kempthorne, O. (1957). *An introduction to Genetic Statistics.* John Wiley and Sone. Inc. New York. USA.

Kempthorne, O. and Curnow, R.N. (1961). The partial diallel cross *Biometrics,* **17** : 229-250.

*Knight, T. A. (1799). An account of some experiments on the foundation of vegetable. *Phil. Trans. Roy. Soc. London.* **89** : 195-204 (C.f. Breeding Crop. Plants H. K. Hayes and Garber.)

*Koelreuter (1763). Cf. CR. Heterosis, Methods of Plant Breeding H. K. hayes, F. r. Immer and D. C. Smith.

Kondra, Z.P. and Stefansson, B.R. (1965). Inheritance of eruric acid eicosenioc acid content of rapeseed oil *(Brassica napus). Canad. J. genet. Cytol.,* 7 : 505-510.

Kumar, P. Dawan, K. Thakral, S.K. and Yadav (1986). Inheritance of free fatty acids in Indian mustard. *J. oil seed Res.* **3**: 182-294.

Kumar, P. and Sinha, M.M. (1987). Inheritance of seed weight in Indian mustard. *J. Oilseed Res.* **4** : 297-299.

Kumar, P.; Yadav, T.P. Yadav, A.K. (1984). Association of seed yield and its component traits in F_2 generation of Indian *J. Agric, Sci.* **54** (7): 604-604.

Kumar, P.; Yadav, T.P.; Gupta, S. K. , Dhawan,K. (1984). Compining ability and genetic architecture of protein content in Indian mustard. *J. Oilseeds Res.* **1** : 57-62.

Kumar, P.R, Arora, R.K.; Singh, N.P.; Yadav, R.C. and Kumar, P.(1990). A study of heterosis in Indian mustard (B. Juncea L. Czern and Cross) *Acta Agronomica Hungarica* **39** : (1-2) 137-143.

Kumar, P.R., Arora, R.K. and Yadav R.C. (1987).Association and path analysis of economic traits in yellow *Sarson J. Oilseed Res.* Hissar, **4** (2) **:** 257-260.

Kumar, P.R., Arora, R.K. and Yadav R.C. and Kumar, P. (1990). Study of hetreosis in Indian mustard (Brassica juncea L. Czern & Coss) *Acta Agronomica Hungarica,* **39**:1-2.

Kumar, P.R. and yadav, T.P.(1978). Selection Criteria for seed yield in *Brassica campestris* (L) *Proceedings* of the *5th International Rapeseed Conference, June* 12-16, 1978 Vol. **1 :** 63-65.

Kumar, P. ; Yadav, T.P.; Yadav, A.K. and Thukral, S.K. (1988).estimates of gene effects with respect to yield and its component traits *J. Oilseeds Res.,* **5:** 72-76.

Kumar, Ravi, Sinhamahapatra, S.P. and Maity Subrata (1997). Genotype x environment interaction in relation to combining ability in Indian mustard. *Indian J. Genet,* **57**: (3) 274-279.

Labana, K.S.; Badwal, S.S. Chaurasia, B.D. (1975). Heterosis and combining ability in Indian mustard. *Crop. Impprov.,* **2** : 46-51.

Labana, K.S.; Chaurasia, B.D. and Singh B. (1980), Genetic variability and inter character association in mutants of Indian mustard, *Indian J. Agric. Sci.* **50**: 803-806.

Labana K.S.; Jindal, S.K. and Mohan, D.K. (1978b). Heterosis and combining ability in yellow sarson *(B. campestris* var. Yellow *sarson*) *Crop. Improv.,* **5** : 50-55.

Labana, S.K.; Jindal, S.K. and Mohan, D.K. (1979). Correlation and path analysis in a diallel cross of *Brassica Campestris c. Var. Yellow sarson. Prain j. Res. P.A.V. Univ.* **16 (2)**: 133-136.

Labana, K.S.; Ram, J.; Badwal, S.S. and Mohan, D.K.(1978a). Combining ability analysis in Indian mustard. *Crop. Improv.,* **5** : 37-44.

Lal, C. and Singh,A.B. (1974). Line x tester analysis in Indian mustard. *Indian J. Agric.Sci.,* **44** (8):50-57.

Lewis, D. (1954) Gene interaction A relationship between dominance, heterosis, phenotypic stability ad variability. *Heredity* **8** : 333-356.

Liv, O.F. and Liv, H.L. (1989). Inheritance of erucic acid and ecosenoic acids in *B. juncea Hereditas, (*Bejing*)* **11** (5) : 17-20.

Liang, G. H. L. (1968). The analysis of lesitable variation for three agronomic traits in a 6 x 6 variety diallel of gram sorghum (*Sorghum vulgare* Pers.) *Canad J. Genet. Cytol.* **10** : 460-469.

Lush, J.L. (1940). Intra-sire correlation or regression of offspring on Dam as a method of estimating heritabilities of characteristics. *Proc. Amer. Soc. Animal, Prod.*, **35** : 293-301.

Lush, J.L. (1943). *Animal Breeding,* Iowa state College. Press Ames Iowa pp. 437.

Lush, J.L. (1949). Heritability of quantitative characters in farm animals. *Proc. 8th Inter. Cong. Genetics Heriditas (Suppl Vol.- I):* 356-375.

Lutfur Rahman (1976). Inheritance of the contents of erucic, ecosenoic, linoleic Linenic and Oleic acids in crosses between and *B. carinata A Br Indian J. Agric.Sci.,* **46** (4): 192-198.

Lefort-Buson M.; Guillot-lemoine, B. and Dattee, Y.(1986). Heterosis and genetic distance in rapeseed. Use of different indicators of genetic divergene in a 7 x 7 diallel. *Agronomics,* **6** (9) : 839-844.

Lefort-Buson, M.; Dattee,Y and Guillot- lemoine, B. (1987). Heterosis and genetic distance in rape (Brassica nupus) use of Kinship coefficient. *Genome,* **29** (1): 11-18.

Malik, R.S. and Singh, Munshi (1988).Combining ability analysis in *Brassica carinata J. Oilseed Res.,* **5** (2) : 29-38.

Mandal, S., Singh R. and Thomas, T.A. (1993). Correlation studies for oil and protein contents in germplasm collections of fine Brassica species. *J. Oilseeds res.* **10**(1) : 139-141.

Mather, K. (1955). The genetical basis of heterosis. *Proc. Roy. Soc. B.* **144**: 143-150.

Mather, K. and Jinks, J.L. (1971). *Biometrical Genetics.* Chapman and Hall Led., Londan.

Matziger,D.F. (1953). Comparison of three types of testers for the evaluation of inbred lines of corn. *Agron. J.* **45**: 493-495.

Matziner, D. F., C. C., Cockerham and E. A. Wernsman (1977). Single character and index mass selection with random mating in naturally self fertilizing species. *Proc. Intl. Confr. Quantitative Genetics.* Iowa State Univ. Press, Ames, Iowa, pp. 503-518.

Miller, P. A., Williams, Jr. J. C., Robinson, H. F. and Comstock, R. E. (1958). Estimates of genotypic and environmental variances and co-variances in upland cotton and their implications in selection. *Agron. J.* **50** : 126-131.

Miller, P.A. and Rawlings, J.C. (1967). Selection for increased lint yield and correlated response in upland cotton *(Gossypisum hirustrum) Crop. Sci.*, **7** : 637-640.

Moll, R.H.; Kindsey, M.F. and Robinson, H.F. (1964). Estimates of genetic variance and level of dominance in maize. *Genetics* **49** : 411-423

Mohammed, A.; Singh, and Alam. S. (1931). Some breeding investigation in Toria. *Indian J. Agric. Sci.,* **1** : 109-131.

*Moss, D.N. Woolley, J.T. and J.F. (1974). Plant modification for more efficeint water use; The challenge. *Agric, Meteoral.*, **14** : 311-320.

Nilson-Ehle., H. (1909). Kreungunter Suchuungon and Hafur and weizen, *Lunds Univ, Arsskr.*, N.F. Afd. 2Bd, SNr. **2 :** pp. 1-122.

Pal, N. K. (1978). Genetic architecture of yield and component of yield in Indian mustard [*Brassica juncea* (L.) *Czern and coss*] *Theor. Appl. Genet.* **53** (5) : 233-237.

Pal, Rishi and Kumar, Prakash (1991), Estimation of gene effect for oil content Indian mustard (*B. juncea*) and normal and late sowing Indian, *J. Agric. Sci.* **61**(12) : 918-921.

Pal, R. and Singh, H. (1980). Combining ability in repeseed Indian. *J. Sci.* **50**: 9-13.

Pal, R. and Singh, H. And Jatsara, D.S. (1981). Genetics of yield and yield components in Indian repeseed *Indian J. Agric. Sci.* **51** : 550-553.

Pal, R. and Singh, H. And Jatsara, D.S. (1983). Inheritance of oil content in rapeseed (B. Campestris L.Var. Toria) *Indian J. Agric. Sci.* **17**: 177-180.

Pal, R. and Singh, Hari (1986). Gene effects for days to flowering, maturity and seed yield in Indian mustard under two environment *J. Oilseed Res.*, **3** : 210-215.

Pandey, V.K. (1974). Line x tester analysis in Indian mustard. *Indian J. Fram Sci.* **2** : 87-89.

Patel, K.M.; Rajpati, K.P. Fatten, U.G. and Patel, I.D. (1993). Combining ability and Heterosis in Indian mustard *J. Oilseed Res.*, **10** (1) : 129-131.

Paul, N.K. (1979). Study of yield and some of its components in F_2 population of rapeseed (*B. Campestris* L.), *Genetica Inerica*, **31**: 23-31.

Paul, N. K.; Joarder, O.I. and Eunus, A. M. (1976a). Analysis of yield and some of its components in Indian mustard *Indian J. Agric Sci.* **46**: 517-524.

*Paul, M. K.; Joarder, O. I. And Eunus, A. M. (1976b). Genetypic and phenotypic variability and correlation studies in *Brassica juncea (L.) Zeitschriff Fur Phlanzenzuchtung*, **77**: 145-159.

Penderson, D. L. (1974). Arguments against intermating before selection in self fertilizing species. *Theor. Appl. Gevet.* **45** : 147-162.

*Podkolzina, V.E. and Shpots, V. I. (1989). Inheritance of oil content of the seeds in Indian mustard freed of erucic acid *nauchno Tekhnicheskii Blylleten Vseoyuznogo nauchno issedovatel skogo institute*, **3**: 21-24.

Prakash, N.; Chauhan, Y. S. and Kumar, K. (1988). Combining ability and path coefficient analysis in F_2 generation in Indian mustard [*B. juncea* (L.) Czern and coss] *Plant Breeding Absets.*, **58** (8): 751.

Prasad, R. and Basudeo Singh (1985). Heterosis for some quantitative characters in Indian reapseed. *Indian J. Agric. Sci.* **55** (11): 671-673.

Quadri, M. I.; Arunachalam, V. and Murty, B. R. (1966). Character association in some self compatible forms of Brassica comestris var. Brown sarson *Indian J. Genet.*, **26**: 170-176.

Rachai, K. O. and C. O. Gardner (1975). Increasing efficiency in breeding partially out-crossing grain legumes, *Symp. Intl. Workshop* Grain Legumes held at ICRISAT, Hyderabad, India. During 1975 pp. 285-297.

Ramanujam, S. and Rai, B. (1963). Analysis of yield component in Brassica campestris vs. yellow sarson. *Ind. J. Genetic.*,**23**: 312-314.

Redden, R. J. and N. F. Jensen (1974). Mass selection and mating system in cereals. *Crop. Sci.* **14** : 345-350.

Richards, R. A. and Thruling, N. (1978a). Variation between and within species of rapeseed (*Brassica campestris and B. napus*) in response to drought stress. I. Sensitivity at different stages of development *Aust. J. Agric. Res.*, **29**: 469-477.

Richards, R. A. and Thruling, N. (1978b). Variation between and within species of rapeseed (*Brassica campestris and B. napus*) response to drought stress. II. Growth and development under natural drought stresses. *Aust. J. Agric. Res.*, **29**: 497-490.

Robinson, H. F.; Comstock, R. E. and Harvey, P. H. (1949). Estimates of heritability and degree of dominance in corn. *Agron. J.* **41**: 353-359.

Robinson, H. F.; Comstock, R. E. and Harvey, P. H. (1951). Genotypic and phenotypic correlation corn and their implications in selection. *Agron. J.*, **43**: 282-287.

Robinson, H. F.; Comstock, R. E. (1955). Analysis of genetic variability in corn with reference to probable effects of selection, cold spearing, *Harbor Symposia on Quantitative Biology*, **20**: 127-136.

Robinson, H. F.; Cockerham, C. C. and Moll, R. H. (1960). Studies on estimation of dominance variance and effects of linkage bias. *Biometrical Genetics*, Pergamon Press, New York, 171-177.

Rawat D. S. and Anand, I. J. (1977). Association of seed yield and oil content with yield components in Indian mustard. *Crop Improv.*, **4**: 95-102.

Rao, T. S. (1977). Genetics of yield components in brown *Sarson. Genetica Iberica*, **29**: 219-227.

Ram, K. and Yadav, T. P. (1986). Combining ability in Indian mustard L. some developmental traits. *J. Oilseed Res.;* **3**(1): 28-36.

Ram, K.; Chauhan, Y. S. and Katiyar, R. P. (1976). Partial diallel analysis in F_3 generation of Indian mustard (*Brassica juncea* L.) Czern and Coss. *Indian J. Agric. Sci.*, **46**(5) 229-232.

Rai, B. (1993). Potentialities of heterosis breeding for the genetic improvement of seed yield in oil seed Brassicas. *Naitonal Seminar on Oilseeds Research and Development in India.* 2-5 Aug. Hyderabad, India.

Rai, B. and Singh, P. K. (1994). Expression of yield heterosis in some inter varietal cross of Indian rapeseed (*Brassica campestris* L. Prain). *Indian J. Genet.*, **54** (3): 310-314.

Ram Bhajan; Chauhan, Y. S. and Kumar, K. (1994). Triple test cross analysis for oil content seed yield and component traits in Indian mustard. *Indian J. Genet.*, **54** (3): 315-316.

Schnell, F. W. (1963). The co-variance between relatives in the presence of linkage. *Statistical genetics and Pl. Breeding NAS-NRC. Publ.*, **982**:468-483.

Sheikh, I. A. and Singh J. N. (1998). Combining ability analysis of seed yield and oil content in Brassica juncea (L) Czern & coss). *Indian J. Genet.*, **58**: (4) : 507-511.

Shivhare, M.D. Singh, A. B.; Chauhan, Y. S. and Singh, P. (1975). Path coefficient analysis of yield components in Indian mustard. *Indian J. Agric. Sci.* **45** (9): 422-425.

Shull, G.H. (1909). A pure line method of corn breeding *Amer. Breed. Asso. Rept.* **5** : 51-59.

Shull, G.H.. (1910). Hybridization method in corn breeding *Amer. Breed. Mag.* **1**: 98-107.

Shull, G.H.. (1914). Duplicate genes for capsule form in *Bruca protories Zuschrin Ukt.* on abst **4**: Veverbungst **12**: 97-149.

Singh, A.B. (1972). Genetic studies of some quantitative character in *Indian mustard* (Brassica Juncaea(L) Czern and Coss). *Unpub. Ph.D.* Thesis, Kanpur University, Kanpur.

Singh, D. (1961). Studies in hybrid vigour and its commercial utilization in rai (B.Juncea). report (Unpuble). *Oilseeds Research Works Cong., Madras.*

Singh, S.P. and Joshi, A.B. (1966) Line x Tester analysis in relation to breeding for yield in linseed. *Indian J. Genet.***26:**177-194

Singh, D. (1973b). Diallel analysis for combining ability over several environments *Indian J. Genets.*, **33** : 469-481.

Singh, D. and Chaudhary, R.K. (1983). Correlation and path coefficient analysis of seed yield and oil content in mustard *(Brassica juncea). J. Gebet. Cytol.* **25** : (3)312-317.

Singh, Dharampal, Singh, D., Singh A.B. and Mishra, S.N. (1969). Relationship among some important agronomic character in Indian mustard [B. juncea) (L). Czern and Coss]. *Indian J. Agric. Sci.* **39**: 362-365.

Singh, Dharampal, Singh D., and Verma, R.S. (1970a). Heritability and degree of dominance in Indian mustard (B.Juncea). *Indian J. Agric. Sci.* **40**: 283-287.

Singh, Dharampal; Singh D.; Singh M.; Pandey, K.N.; Singh, A.B. and Singh, S.P. (1970b). Diallel cross analysis of some important agronomic characters in Indian colza (b. *campestris var yellow Sarson Prain). Indian J. Agric. Sci.,* **39** 362-365.

Singh Dharampal; Singh, D. Singh, I.S.; Singh, H. Singh, S.P. and Singh, A.B. (1971). Diallel analysis in yellow Sarson (B.campestris (L) Var. Yellow *Sarson* Prain). *Indian J. Agric. Sci.,* **41** : 315-323.

Singh, D. Sachan, J.N.; Bhajans, R.S.; Singh B. and Singh, S.P. (1986). Combining ability in Indian mustard *J. Oilseeds Res.,* **3** : 1-7.

Singh, G.P. (1991). Genetics of yield and quality parameters in Indian mustard (*Brassica juncea)* (L). Czern and Coss). *Unpubl. Ph.D. Thesis C.S. Azad Univ. of Agric. And Tech.* Kanpur.

Singh, H. (1986). Genetic variability and drought index analysis in *Brassica species. J. Oilseed Res.* **3**: 170-177.

Singh, Harbir, Singh, S.P.; Singh, P.K.; Rao, D.S. and Singh, R.M. (1990). Correlation and path coefficient of see yield and its components in toria (*B.camestris) H.A.V. Deptt. of Agronomy Research Report.*

Singh., H. and Yashpal, (1991). Genetic components and combining ability analysis of oil content in Indian mustard. *J. Oilseeds Res.* **8** (1): 117-120.

Singh, J.N. Yadava, M.C. and Sheikh. I.A. (1996). Genetical studies per yield and oil content in *Brassica juncea* (L) Czern & Coss. Indian *J. Genet.,* **56** (3): 299-304.

Singh, K.N.; Santoshi, U.S. and Singh, I.B.(1985). Path coefficient study in pea (Pisum sativum L.) *Indian J. Genet.,* **45** (3): 494-504.

Singh, R.A. and Hari Singh (1985). Combining ability and heterosis for seed yield and its component characters in Indian mustard sown early late. *Indian J. Agric. Sci.* **5** (5): 309-315.

Singh, Karan and Verma, O.P. (1998). Genetic behaviour of yield and its components in Indian mustard. *J.Oilseeds Res.* **15:**(2):343-344.

Singh, R.M., Singh, H.C.; Talukdar, B.S. Chauhan, Y.S. and Singh A.K. (1975). Heterosis in Indian mustard (*Brassica junceaO. Pl. Breeding Abst.,* **45** (2): 115.

Singh R.N. and Srivastava, A.N. (1986). Combining ability analysis for yield and its components in Indian mustard. *Farm. Sci., J.* **1** (1-2): 52-57.

Singh, R.P., Singh, D.P. and Chaudhary, B.D. (1988). Morphophysio logical variation in Indian mustard. *M.A.T. Agric. H.A.V.* **12**(13): 33.

Singh, R.S.; Singh, O.N. and Chaudhary, R.K. (1985). Combining ability for yield in Indian mustard, *Indian J. Agric., Sci.* **55** (4): 240-242.

Singh, R.S., Chaudhary, R.A. and Singh, O.N. (1983). Heterobilities in relation to *Per se* performance and effect of general combining ability in rai, *Pl. Breeding Abst.,* **54**: 526-1984.

Singh. R.S., Singh, P. and Dixit, R.K. (1987). Combining ability analysis of yield and developmental traits in Indian colza (*B.campestris* (L), Var, yellow sarson Prain). *Farm Sci. J.;* **2**(2): 170-174.

Singh, S. and Singh, Dharampal (1972). Inheritance of yield and other agronomic character in Indian mustard (*Brassica juncea).* Canad *J. Genet, Cytol.* **14:** 227-233.

Singh, Shreepal, (1973). Heterosis and combining ability estimates in Indian mustard (*Brassica Juncea* L. Czern and Coss) Crop. Sci., **13:** 496-499.

Smith, H.H. (1952). Fixing transgressive vigour in *Nicotiana rustica*. In *heterosis*. Ed. J.W.Groven. Iowa St. Coll. Press Ames, Iowa, pp 166-174.

Sprague, G.E. and Tatum. L.A. (1942). General versus specific combining ability in single crosses of corn *J.Amer, Scc. Agron.*, **34:** 923-932.

Sprague, G.F. (1966). Quantitative genetics in plant improvement. *Quantitative Genetics and Plant Breeding*. A symposium on plant breeding held at Iowa State University, the Iowa State *University* Press. Ames. Iowa, pp 315-354.

Srivastava, A.N.; Wani, S.A. Dixit, R.K. (1983). Genetic association in Indian mustard. *Indian J. Agric. Sci.* **53** (9): 778-781.

Stebbins, G.L. Ir. (1950). Variation and evaluation in plants *Coulumbia Univ. Press*. New York.

Stringfield, G.F.(1950) Hetrozygosis andgybrid vigour in Maize *Argon J.* **42**: 145- 152

Sudhakar, S.P.; srivastava, A.N. Katiyar, R.P. (1979). Path analysis in Indian calza (Brassica campestris var *sarson* Prain). *Indian J. Genetics.*

Tak, G.M. (1976). Correlation and path coefficient analysis of the yield components in three forms of (*Brassica campestris* (L.). *Crop Improv.* **3** (1/2): 43-52.

Thakral, N.K. (1982). To study the association of some marphophysiological attributes with yield in toria *(B. campestris var toria)*. Thesis Absts., **8:** 66-67.

Thakral, N.K. and Kumar Prakash (1998). Combining ability for vigour characters under normal and saline environments in Indian mustard *(Brassica juncea*(L) Gzern & Coss). *J. oilseeds res.,* **15** (2): 234-237.

Thakur, H.L. Zerger, M.A. and Rana, N.D. (1989). Combining ability for economic traits in Indian mustard. *J. oilseed Res.* **6:** 40-41.

Tiwari, L.P. and Singh A.B. (1973). Diallel cross analysis of quantitative traits in Indian mustard *[Brassica juncea (*L.) Czern and Coss]. *Indian J. Agric. Sci.,* **43:** (12): 1055-1059

Tiwari, L.P. and Singh, A.B. (1975). Combining ability studies in *Indian* mustard (*Brassica juncea* (L.) Czern and coss). *Indian J. Agric. Res* **9** : 171-176.

Thurling,B.N. (1974). Morphophysiological determinates of yield in rape seed.*Aust J. Agric.Res.*, **25** : 697-710.

Turbin, N.V. (1963). Heterosis and genetic balance. *Genetics Today* Proc XI Intern. Congr. Genetics. The Hange pp. 149-150.

Varshney, S. and Singh, B. (1983). Interrelation–ship among harvest index and other quantitative traits in toria (*B.campestris* (L.) var. toria). SARRAO, **14**: 89-92.

Varshney, S.K. Rai. B. and Singh,B. (1990). Analysis of harvest indeed in three cultivated species of Brassica. *Indian J.Genet*. **50** (3): 289-295.

Varshney, S.K. and Rao, C.S. (1997). Combining ability, heterosis and inbreeding depression for yield components in yellow sarson, *Indian J. Genet.*, **57** (1) : 91-97.

*Vahtin, J.B. (1964). Inheritance of combining ability in maize when self pohtinated and selected for covlinese. *B. Julf. Inst. Biol. Akod. Nank. Bolorussk.* **4** : 209-216.

Verma, N.K. Singh, Basudeo and Sachan, J.N.(1989). Combining ability and heterosis in yellow sarson. *J. Oilseed Res.* **6** :32-40.

Verma, O.P.; Singh, R.K.; Singh Karan; Singh P.V. (1992). Gene effects, for six matric traits in Indian Mustard (Brassica juncea). *Indian J. Agric. Sci.* **62(12):** 827-829.

Wahhab, M.A. and Bachyne, M.(1977). Heritability estimates for some yield contributing characters in Indian mustard. *Indian. J. Agric. Sci.* **47** (11): 556-562.

*Wang, F. and Qui, J. (1990). Studies on the inheritance of seed protein content and tits content and this correlation with other character in *Brassica napus Scientist Agriculture Sinica,* **23** (6): 42-47.

Wani, S.A. and Srivastava, A.N. (1989). Combining ability analysis in Indian mustard, *Crop. Imporv.* **16** (1) : 72-75.

Warner J. N. (1952). A method of estimating heritability. *AgronJ.*, **44**: 427-430.

Whaley, W.G. (1944) heterosis . Bot. Review., **10**: 461-498. " *In heterosis*" (E.d.) Gower G.W., Halfure, Inc. New York. P. 104.

Weatherly, P.F. and Baltyer, R.O. (1957). Relationship between relative turgidity and diffusion pressure deficit in leaves *Nature.*, **179**:1083-1086.

Weber, C.R. (1952). Heritability and non- heritable relationship and variability of oil content and agronomic characters in F_2 generation of Soyabeen crosses. *Agron. J.* **44**: 202-209.

Whitehouse R.N.S.; Thompson, J.B. and Reberio, D.R. (1958). Studies on the breeding of self- pollinated cereals. The use of diallal cross analysis in yield predication *Euphytica* **1**: 147-169.

Williams, W. (1959). Heterosis and genetics of complex characters, *Nature* **184**: 527-530.

Williams, W. and Gilbert, N. (1960). Heterosis and inheritance of yield in tomato. *Heredity,* **14** : 133-149.

Wright , S. (1921). Correlation and causation . J. Agric. Res. **20**: 551-558.

Wright, S. (1922). The effects of inbreeding and coss breeding in guine pigs. III. Crosses between highly inbreed families *U.S. Deptt. Agric. Tech Bull* **1121**: 61.

William, W. (1959). Heterosis and genetic of complex characters *Nature* **184**: 527-530.

Yadav, T.P. and Gupta, V.P. (1975). Heterosis and genetic architecture for oil content in mustard . *Indian J. genet.* and *Pl. Breed* **35** : 152-155.

Yadav, T.P.; Singh, Hari, Gupta,V.P. and Rana, R.K. (1977). Heterosis and combining ability in raya and its components. *Plant Breeding Absts.* , **47** (6): 482.

Yadava, T.P.; Yadava, A. K. and Kumar, P. (1981). Estimation of gene effects of oil content in Indian mustard (Brassica juncea L. Czern & coss*).* *Haryana Arril Univ*. J. Res., **11** : 339-343.

Yadav, N. (1982). Correlation coefficient and selection indices in brown *Sarson (Brassica compestive h.)* Thesis *Abstracts*. **8** : 184.

Yadav, C.K. (1983), studies on genetics of yield and its components in Indian mustard. (*Brassica juncea* H. Czern coss.) Thesis Abstracts *Hissar Agric. Univ,* Hissar **9** : 186-187.

Yadav, T.P.; Gupta, S.K.; Thakral, S.K. and Kumar, P. (1983). Association of seed yield with some quality attributes in Indian mustard. *Indian J. Agric. Sci.* **53** (7): 685-6 86.

Yadav, A.K.; Singh, Hari and Yadav, I.S. (1990). Genetical analysis of havvost index, biological yield and seed yield in Indian mustard. (*B. junecea* h. Czern and coss) *J. Oilseed Res.*, **7** (1): 16-20.

Yadav, O.P.; Yadav, T.P. and Kumar, Prakash (1992). Combining ability for yield its component characters and oil content in Indian mustard. (*B. juncea* (L.) Czern and coss) *J. Oilseed Res.* **9** (1): 14-20.

Zuberi, M.L., and S.V. Ahmad (1973). Genetic study of yield and some of its components in *Brassica campestris* L.var. *toria Crop.Sci.*,**13:**13-15.

* Original not seen.

CHAPTER 8

TABLES

Table 1: List of Strains / Varieties used in the Line x Tester mating design of India mustard

S.N.	train/Variety	Source	Pedigree
	Lines		
1.	**RK 8601**	CSAUA&T, Kanpur	Selection from Kanpur
2.	**RK 8602**	CSAUA&T, Kanpur	Selection from Kanpur
3.	**RK 8604**	CSAUA&T, Kanpur	Selection from Kanpur
4.	**RK 8605**	CSAUA&T, Kanpur	Selection from Aligarh
5.	**RK 8608**	CSAUA&T, Kanpur	Selection from Kanpur
6.	**RK 8701**	CSAUA&T, Kanpur	Varuna x RK 1467
7.	**RK 8702**	CSAUA&T, Kanpur	Selection from Agra
8.	**RK 8801**	CSAUA&T, Kanpur	Varuna x PR- 15
9.	**RK 8802**	CSAUA&T, Kanpur	Varuna x T-6332
10.	**RK 8803**	CSAUA&T, Kanpur	RK- 1467 x PR 18
11.	**RK 8901**	CSAUA&T, Kanpur	Varuna x Seeta
12.	**RK 8902**	CSAUA&T, Kanpur	RH- 30 x Varuna
13.	**RK 8903**	CSAUA&T, Kanpur	Varuna x Vardan
14.	**RK 9001**	CSAUA&T, Kanpur	RK- 1467 x RC- 781
15.	**RK 9002**	CSAUA&T, Kanpur	Selection from Hamirpur
16.	**RK 918506**	CSAUA&T, Kanpur	Selection from Hamirpur District
17.	**RK 911296**	CSAUA&T, Kanpur	Selection from Kanpur
18.	**RK 9**	CSAUA&T, Kanpur	Selected variant from Varuna
19.	**RK 14**	CSAUA&T, Kanpur	Selected variant from Varuna
20.	**KRV 47**	CSAUA&T, Kanpur	Selected variant from Varuna
	Testers		
21.	**Mathura Rai**	CSAUA&T, Kanpur	Selection from Mathura
22.	**Laha 101**	CSAUA&T, Kanpur	Selection from Aligarh
23.	**Vaibhav**	CSAUA&T, Kanpur	Biparental matings of Varuna x Keshri CS 410 and 1B 1175, 1B 1866, 1B 1786

Table. 2: ANOVA for 13 characters in two environments for F_1 and F_2 generation of Indian mustard : Mean sum of squares

(i) Days to flowering

Source of variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Replication	02	14.65**	69.00**	61.94**	51.78**
Treatment	82	19.15**	18.96**	31.23**	15.50**
Error	164	1.81	4.83	0.47	2.86

(ii) Days to reproductive phase

Source of variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Replication	02	38.06**	44.25**	382.15**	602.78**
Treatment	82	61.178**	56.89**	23.70**	18.96**
Error	164	8.31	15.82	1.71	1.16

(iii) Number of primary branches

Source of variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Replication	02	4.35*	6.65**	2.00	3.31*
Treatment	82	11.35**	3.74**	5.86**	5.35**
Error	164	1.83	1.05	1.33	0.94

(iv) Number of secondary branches

Source of variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Replication	02	10.28*	12.89**	3.30*	4.93**
Treatment	82	108.95**	39.90**	31.50**	11.41**
Error	164	2.85	2.83	0.91	0.92

(v) Height of plant

Source of variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Replication	02	336.00**	189.00**	312.00**	134.25**
Treatment	82	551.40**	362.56**	1046.86**	529.47**
Error	164	47.71	46.67	2.30	3.02

(vi) Length of main fruiting branch

Source of variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Replication	02	37.43**	47.18**	17.25**	68.65**
Treatment	82	348.17**	340.30**	61.18**	90.79**
Error	164	3.97	7.54	2.91	4.34

(vii) Number of Siliquae on main fruiting branch

Source of variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Replication	02	166.84**	163.56**	37.47**	44.22**
Treatment	82	250.01**	211.38**	93.13**	86.15**
Error	164	6.44	4.59	3.29	2.69

Table 2 Contd.

(viii) Days to maturity

Source of variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Replication	02	75.87**	87.62*	9.13	66.94**
Treatment	82	95.67**	471.57**	34.40**	50.69**
Error	164	6.02	16.43	5.37	3.99

(ix) Relative water content

Source of variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Replications	02	0.01	0.13	0.06	0.47
Treatments	82	108.79**	109.63**	28.35**	28.86**
Error	164	1.71	3.83	5.44	0.99

(x) Leaf water potential

Source of variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Replication	02	0.01	0.22	0.01	0.32
Treatment	82	1.51**	2.70**	2.41**	4.24**
Error	164	0.01	0.11	0.01	0.01

(xi) Yield per plant

Source of variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Replication	02	19.63**	201.81**	23.08	02.76
Treatment	82	1138.36**	443.21**	355.58**	143.04**
Error	164	7.59	5.50	8.78	1.92

(xii) Oil Content

Source of variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Replication	02	28.05**	13.55**	2.67	4.41*
Treatment	82	56.03**	40.87**	19.88**	16.80**
Error	164	1.62	1.31	1.00	1.10

(xiii) Erucic acid

Source of variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Replication	02	0.11	0.37	0.93	0.03
Treatment	82	0.76**	1.28**	2.24**	0.19**
Error	164	0.23	0.21	0.72	0.07

* Significant at p=0.05; ** Significant at p=0.01

Table 3: AN0VA for pooled data of 13 characters grown in two environments for F_1 and F_2 generation in Indian mustard: Mean sum of squares

Source of Variation	df.	Days to flowering		Days to reproductive phase	
		F_1	F_2	F_1	F_2
Environments (E)	1	708.62**	1395.87**	43506.38**	87061.72**
Replications (R)	4	57.69**	53.34**	80.87**	98.85**
Crosses (C)	59	47.32**	30.02**	59.17**	54.71**
C x E	59	4.55	4.71	14.14	5.53
Error	328	15.01	9.06	18.68	20.64

Source of Variation	df.	Number of primary branches		No of secondary branches	
		F_1	F_2	F_1	F_2
Environments (E)	1	496.20**	295.79**	11498.90**	7619.89**
Replications (R)	4	3.17**	4.98**	6.79**	8.91**
Crosses (C)	59	15.14**	4.65**	125.82	41.29**
C x E	59	3.57**	2.30**	11.37**	3.99**
Error	328	1.48	0.99	1.88	1.88

Source of variation	df.	Height of plant		Length of main fruiting branch	
		F_1	F_2	F_1	F_2
Environments (E)	1	55838.57**	60098.92**	99583.30**	49316.65**
Replications (R)	4	261.56**	361.57**	61.12	461.19**
Crosses (C)	59	1201.28**	478.40**	235.46**	338.51**
C x E	59	260.29**	259.01**	29.84**	76.46**
Error	328	68.81	74.71	20.63	17.19

Source of Variation	df.	No of siliquae on main fruiting branch		Days to maturity	
		F_1	F_2	F_1	F_2
Environments (E)	1	68508.59**	63354.77**	37170.34**	25454.69**
Replications (R)	4	102.18**	103.88**	894.10**	488.48**
Crosses (C)	59	294.76**	216.84**	184.84**	264.62**
C x E	59	27.13**	20.07**	129.41**	163.37**
Error	328	4.86	3.64	71.57	50.20

Table 3 Contd.

Source of Variations	df.	Relative water content		Leaf water potential	
		F_1	F_1	F_1	F_2
Environments (E)	1	211753.50**	214381.30**	135.90**	155.20**
Replications (R)	4	0.03	0.06	0.01	0.20*
Crosses (C)	59	131.38**	132.07**	4.11**	7.80**
C x E	59	13.81**	15.00**	0.09*	0.10*
Error	328	1.07	2.42	0.08	0.10

Source of variation	df.	Yield per plant		Oil Content	
		F_1	F_2	F_1	F_2
Environments (E)	1	59184.83**	30417.00**	13351.80**	12802.90**
Replications (R)	4	21.37**	132.29**	15.40**	8.98**
Crosses (C)	59	1247.05**	624.38**	36.78**	21.13**
C x E	59	108.68**	47.37**	5.59**	3.02**
Error	328	8.18	3.71	1.31	1.20

Source of variation	df.	Erucic Acid	
		F_1	F_2
Environments (E)	1	6.34**	5.07**
Replications (R)	4	0.16	0.38
Crosses (C)	59	1.44**	0.51**
C x E	59	1.17**	0.59**
Error	328	0.89	0.41

*Significant at p = 0.05; ** Significant at p = 0.01

Table 4 : ANOVA for combining ability and related statistics for 13 characters in two environments for F_1 and F_2 generations of Indian mustard: Mean sum of squares

Days to flowering

Source of Variation	df	Normal sown (E_1)		Late sown (E_2)	
		F_1	F_2	F_1	F_2
Females (F)	19	23.03**	14.57**	66.33**	15.17**
Males (M)	2	30.26**	131.28**	16.59**	40.01*
F x M	38	18.99**	15.66**	14.41**	14.38**
Error	118	4.61	3.89	3.36	2.86
Cov. (H.S)		1.72	1.65	1.78	1.38
Cov. (F.S)		4.43	7.24	5.25	4.60
$\hat{\sigma}^2_f$		0.45	-0.12	5.77	0.09
$\hat{\sigma}^2_m$		0.19	1.93	0.04	0.43
$\hat{\sigma}^2_{fm}$		1.87	3.92	3.69	3.84
$\hat{\sigma}^2_g$		3.45	3.32	3.56	2.76
$\hat{\sigma}^2_s$		7.50	15.69	8.00	7.72
$\hat{\sigma}^2_A$		6.89	6.64	7.12	5.52
$\hat{\sigma}^2_D$		7.50	7.85	8.00	4.36
$\hat{\sigma}^2_A / \hat{\sigma}^2_D$		0.92	0.85	0.89	1.26
$\sqrt{\hat{\sigma}^2_D / \hat{\sigma}^2_A}$		1.04	1.09	1.06	0.89

Days to reproductive phase

Source of Variation	df	Normal sown (E_1)		Late sown (E_2)	
		F_1	F_2	F_1	F_2
Females (F)	19	60.21**	51.13**	29.29**	25.37**
Males (M)	2	92.17**	37.77**	20.16**	7.81**
F x M	38	42.07	36.53**	21.09**	16.36**
Error	118	2.52	2.58	1.71	1.16
Cov. (H.S)		1.60	0.96	1.11	0.67
Cov. (F.S)		4.82	5.34	6.67	5.07
$\hat{\sigma}^2_f$		2.02	1.62	0.91	1.00
$\hat{\sigma}^2_m$		0.83	0.02	-0.02	-0.14
$\hat{\sigma}^2_{fm}$		11.85	8.00	6.46	5.07
$\hat{\sigma}^2_g$		3.20	1.92	2.22	1.34
$\hat{\sigma}^2_s$		10.27	10.92	5.21	20.26
$\hat{\sigma}^2_A$		6.40	3.84	4.44	2.68
$\hat{\sigma}^2_D$		10.27	5.46	8.21	10.13
$\hat{\sigma}^2_A / \hat{\sigma}^2_D$		0.62	0.70	0.54	0.26
$\sqrt{\hat{\sigma}^2_D / \hat{\sigma}^2_A}$		1.27	1.19	1.36	1.94

Table 4 : Contd.

Number of primary branches

Source of Variation	df	Normal sown (E_1)		Late sown (E_2)	
		F_1	F_2	F_1	F_2
Females (F)	19	10.44**	3.10	4.99**	1.40
Males (M)	2	15.50**	13.10**	6.25**	8.65**
F x M	38	10.48**	2.75**	5.06**	1.57**
Error	118	1.93	0.92	0.91	0.66
Cov. (H.S)		0.07	0.15	0.02	0.10
Cov. (F.S)		2.99	0.92	1.41	0.50
$\hat{\sigma}^2_f$		0.01	0.04	-0.01	-0.02
$\hat{\sigma}^2_m$		0.08	0.17	0.02	0.12
$\hat{\sigma}^2_{fm}$		2.85	0.61	1.38	0.30
$\hat{\sigma}^2_g$		0.15	0.31	0.03	0.20
$\hat{\sigma}^2_s$		11.40	2.43	5.53	1.21
$\hat{\sigma}^2_A$		0.29	0.62	0.06	0.40
$\hat{\sigma}^2_D$		11.40	1.20	5.53	0.61
$\hat{\sigma}^2_A / \hat{\sigma}^2_D$		0.03	0.25	0.01	0.32
$\sqrt{\hat{\sigma}^2_D / \hat{\sigma}^2_A}$		6.27	1.98	9.60	1.74

Number of secondary branches

Source of Variation	df	Normal sown (E_1)		Late sown (E_2)	
		F_1	F_2	F_1	F_2
Females (F)	19	114.62**	60.58**	3.00**	16.80**
Males (M)	2	129.76**	66.07*	41.60**	17.15**
F x M	38	15.86**	21.15**	9.32**	6.07**
Error	118	2.71	2.79	0.82	0.87
Cov. (H.S)		0.62	1.22	0.23	0.32
Cov. (F.S)		33.95	8.56	9.96	2.36
$\hat{\sigma}^2_f$		1.53	4.38	0.41	1.20
$\hat{\sigma}^2_m$		0.48	0.75	0.20	0.18
$\hat{\sigma}^2_{fm}$		32.72	0.12	9.50	0.73
$\hat{\sigma}^2_g$		1.24	2.45	0.46	0.63
$\hat{\sigma}^2_s$		130.86	27.48	3.99	6.93
$\hat{\sigma}^2_A$		2.47	4.89	0.93	1.27
$\hat{\sigma}^2_D$		130.86	13.74	37.99	3.47
$\hat{\sigma}^2_A / \hat{\sigma}^2_D$		0.02	0.20	0.02	0.18
$\sqrt{\hat{\sigma}^2_D / \hat{\sigma}^2_A}$		7.28	2.24	6.39	2.33

Table 4 : Contd.

Height of plant

Source of Variation	df	Normal sown (E_1)		Late sown (E_2)	
		F_1	F_2	F_1	F_2
Females (F)	19	474.15**	226.60	1447.43**	482.88**
Males (M)	2	61.20**	56.10**	20.59**	18.44
F x M	38	340.47**	205.44**	891.08**	565.39**
Error	118	4.92	8.70	2.29	3.02
Cov. (H.S)		21.20	3.53	18.60	5.19
Cov. (F.S)		102.41	55.84	192.40	77.06
$\hat{\sigma}^2_f$		14.85	2.35	61.82	-9.17
$\hat{\sigma}^2_m$		15.35	-2.11	-11.49	-4.60
$\hat{\sigma}^2_{fm}$		51.85	-58.91	296.26	187.46
$\hat{\sigma}^2_g$		42.40	7.06	37.20	-10.34
$\hat{\sigma}^2_s$		170.42	35.65	110.05	41.60
$\hat{\sigma}^2_A$		84.80	14.13	74.04	-20.68
$\hat{\sigma}^2_D$		170.42	17.83	110.05	20.80
$\hat{\sigma}^2_A / \hat{\sigma}^2_D$		0.50	0.79	0.68	NV
$\sqrt{\hat{\sigma}^2_D / \hat{\sigma}^2_A}$		1.42	1.12	1.22	NV

Length of main fruiting branch

Source of Variation	df	Normal Sown (E_1)		Late Sown (E_2)	
		F_1	F_2	F_1	F_2
Females (F)	19	155.23**	441.29**	51.08**	93.25**
Males (M)	2	105.08**	69.15**	93.82**	64.95**
F x M	38	228.50**	252.74**	64.51**	80.49**
Error	118	19.78	4.24	17.02	4.34
Cov. (H.S)		1.40	7.31	0.23	2.85
Cov. (F.S)		6.77	27.45	4.29	11.09
$\hat{\sigma}^2_f$		-8.14	20.95	-1.49	1.40
$\hat{\sigma}^2_m$		-0.39	5.27	0.49	3.07
$\hat{\sigma}^2_{fm}$		69.57	82.83	15.83	25.39
$\hat{\sigma}^2_g$		-2.81	14.77	-0.46	5.92
$\hat{\sigma}^2_s$		20.48	331.32	3.32	60.94
$\hat{\sigma}^2_A$		-5.61	29.27	-0.92	11.42
$\hat{\sigma}^2_D$		20.48	165.66	3.32	30.47
$\hat{\sigma}^2_A / \hat{\sigma}^2_D$		NV	0.18	NV	0.37
$\sqrt{\hat{\sigma}^2_D / \hat{\sigma}^2_A}$		NV	2.38	NV	1.63

Table 4 : Contd.

Number of siliquae on main fruiting branch

Source of Variation	df	Normal sown (E_1)		Late sown (E_2)	
		F_1	F_2	F_1	F_2
Females (F)	19	259.75**	361.21**	72.84**	102.83**
Males (M)	2	49.33**	3.81	3.31	0.74
F x M	38	92.29**	105.24**	26.36**	30.32**
Error	118	7.97	5.28	2.20	1.38
Cov. (H.S)		1.86	2.24	0.54	0.62
Cov. (F.S)		81.16	37.80	23.47	10.89
$\hat{\sigma}^2_f$		2.16	28.44	0.39	8.06
$\hat{\sigma}^2_m$		1.82	-1.69	0.57	-0.49
$\hat{\sigma}^2_{fm}$		77.44	33.32	22.29	9.65
$\hat{\sigma}^2_g$		3.73	4.48	1.08	1.24
$\hat{\sigma}^2_s$		309.75	133.28	89.54	38.58
$\hat{\sigma}^2_A$		7.45	8.96	2.17	2.49
$\hat{\sigma}^2_D$		309.75	133.28	89.54	38.58
$\hat{\sigma}^2_A / \hat{\sigma}^2_D$		0.02	0.07	0.02	0.06
$\sqrt{\hat{\sigma}^2_D / \hat{\sigma}^2_A}$		6.45	3.86	6.42	3.94

Days to maturity

Source of Variation	df	Normal sown (E_1)		Late sown (E_2)	
		F_1	F_2	F_1	F_2
Females (F)	19	118.08**	1378.65**	42.84**	26.13**
Males (M)	2	41.96**	161.95**	8.28	18.65**
F x M	38	62.74**	43.21**	31.55**	60.51**
Error	118	5.77	1.01	5.47	3.99
Cov. (H.S)		2.50	4.10	3.05	3.22
Cov. (F.S)		4.99	06.21	8.34	08.91
$\hat{\sigma}^2_f$		6.15	148.38	1.25	-3.82
$\hat{\sigma}^2_m$		-0.35	1.98	-0.39	0.62
$\hat{\sigma}^2_{fm}$		18.99	14.07	8.69	18.84
$\hat{\sigma}^2_g$		5.00	8.20	6.10	6.45
$\hat{\sigma}^2_s$		15.67	56.28	13.25	22.70
$\hat{\sigma}^2_A$		10.00	16.40	12.20	12.90
$\hat{\sigma}^2_D$		15.67	28.14	13.25	11.35
$\hat{\sigma}^2_A / \hat{\sigma}^2_D$		0.64	0.58	0.92	0.14
$\sqrt{\hat{\sigma}^2_D / \hat{\sigma}^2_A}$		1.57	1.31	1.04	0.94

Table 4 : Contd.

Relative water content

Source of Variation	df	Normal sown (E_1)		Late sown (E_2)	
		F_1	F_2	F_1	F_2
Females (F)	19	183.70*	157.67*	34.79**	39.23**
Males (M)	2	17.42	63.78	4.26	8.82
F x M	38	70.13**	98.45**	28.98**	27.65**
Error	118	1.80	4.77	0.47	1.24
Cov. (H.S)		1.03	0.35	-0.27	-0.10
Cov. (F.S)		34.38	31.94	8.95	8.59
$\hat{\sigma}^2_f$		2.51	6.58	0.65	1.29
$\hat{\sigma}^2_m$		-1.56	-0.58	-0.41	-0.31
$\hat{\sigma}^2_{fm}$		36.44	31.32	9.50	8.80
$\hat{\sigma}^2_g$		-2.06	0.71	-0.55	-0.21
$\hat{\sigma}^2_s$		145.77	124.91	38.02	35.22
$\hat{\sigma}^2_A$		-4.12	1.42	-1.10	-0.42
$\hat{\sigma}^2_D$		145.77	62.46	38.02	17.61
$\hat{\sigma}^2_A / \hat{\sigma}^2_D$		NV	0.01	NV	NV
$\sqrt{\hat{\sigma}^2_D / \hat{\sigma}^2_A}$		NV	9.38	NV	NV

Leaf water potential

Source of Variation	df	Normal sown (E_1)		Late sown (E_2)	
		F_1	F_2	F_1	F_2
Females (F)	19	2.90**	1.00*	4.40**	4.50*
Males (M)	2	16.20**	4.60**	3.70*	7.30*
F x M	38	1.20**	1.40**	1.90**	2.30**
Error	118	0.20	0.20	0.20	0.30
Cov. (H.S)		0.20	0.02	0.20	0.20
Cov. (F.S)		0.40	1.10	0.70	1.80
$\hat{\sigma}^2_f$		0.30	-0.20	0.40	-0.20
$\hat{\sigma}^2_m$		0.10	0.10	0.10	0.10
$\hat{\sigma}^2_{fm}$		0.30	1.00	0.90	1.80
$\hat{\sigma}^2_g$		0.10	0.10	0.10	0.10
$\hat{\sigma}^2_s$		1.40	4.30	2.40	6.70
$\hat{\sigma}^2_A$		0.20	0.20	0.20	0.20
$\hat{\sigma}^2_D$		1.40	2.20	2.40	3.40
$\hat{\sigma}^2_A / \hat{\sigma}^2_D$		0.10	0.10	0.50	0.20
$\sqrt{\hat{\sigma}^2_D / \hat{\sigma}^2_A}$		0.10	0.10	48.10	81.30

Table 4 : Contd.

Yield per plant

Source of Variation	df	Normal sown (E_1)		Late sown (E_2)	
		F_1	F_2	F_1	F_2
Females (F)	19	1541.07**	1120.97**	492.84*	361.49**
Males (M)	2	380.52**	74.17**	67.44**	25.55**
F x M	38	812.05**	223.87**	252.36**	72.64**
Error	118	7.75	5.43	11.40	1.95
Cov. (H.S)		4.31	10.83	0.80	3.50
Cov. (F.S)		276.72	94.48	81.93	30.57
$\hat{\sigma}^2_f$		81.00	99.68	26.72	32.09
$\hat{\sigma}^2_m$		-7.19	-2.50	-3.08	-0.78
$\hat{\sigma}^2_{fm}$		268.10	72.81	80.32	23.57
$\hat{\sigma}^2_g$		8.63	21.66	1.61	70.01
$\hat{\sigma}^2_s$		1072.40	291.27	321.28	94.24
$\hat{\sigma}^2_A$		17.25	43.33	3.22	14.02
$\hat{\sigma}^2_D$		1072.40	145.64	321.28	47.12
$\hat{\sigma}^2_A / \hat{\sigma}^2_D$		0.02	0.15	0.01	0.15
$\sqrt{\hat{\sigma}^2_D / \hat{\sigma}^2_A}$		7.88	2.59	9.99	2.59

Oil content

Source of Variation	df	Normal sown (E_1)		Late sown (E_2)	
		F_1	F_2	F_1	F_2
Females (F)	19	47.44**	27.59**	9.90**	4.50**
Males (M)	2	16.50**	23.17**	1.96*	4.40**
F x M	38	9.42**	10.20**	3.12**	4.81**
Error	118	1.61	1.12	0.58	0.73
Cov. (H.S)		0.07	0.01	- 0.02	-0.01
Cov. (F.S)		9.41	0.06	2.00	1.34
$\hat{\sigma}^2_f$		2.00	-0.29	0.35	-0.03
$\hat{\sigma}^2_m$		- 0.22	0.05	-0.08	-0.01
$\hat{\sigma}^2_{fm}$		9.27	6.35	2.05	1.37
$\hat{\sigma}^2_g$		0.15	0.01	-0.04	-0.02
$\hat{\sigma}^2_s$		37.07	25.42	8.21	5.43
$\hat{\sigma}^2_A$		0.30	0.02	-0.09	-0.04
$\hat{\sigma}^2_D$		37.07	12.75	8.21	2.72
$\hat{\sigma}^2_A / \hat{\sigma}^2_D$		0.01	0.01	NV	NV
$\sqrt{\hat{\sigma}^2_D / \hat{\sigma}^2_A}$		11.12	35.65	NV	NV

Table 4 : Contd.

Erucic acid

Source of Variation	df	Normal sown (E_1)		Late sown (E_2)	
		F_1	F_2	F_1	F_2
Females (F)	19	0.25*	0.20*	0.13**	0.09*
Males (M)	2	0.10	0.06	0.05	0.05
F x M	38	0.34**	0.28**	0.20**	0.21**
Error	118	0.08	0.06	0.04	0.03
Cov. (H.S)		0.02	0.01	0.03	0.02
Cov. (F.S)		0.02	0.02	0.03	0.01
$\hat{\sigma}^2_f$		0.03	0.03	0.28	0.01
$\hat{\sigma}^2_m$		0.01	0.01	0.01	0.01
$\hat{\sigma}^2_{fm}$		0.08	0.08	0.03	0.52
$\hat{\sigma}^2_g$		0.05	0.04	0.06	0.04
$\hat{\sigma}^2_s$		0.06	0.14	0.16	0.14
$\hat{\sigma}^2_A$		0.10	0.08	0.12	0.08
$\hat{\sigma}^2_D$		0.06	0.07	0.10	0.07
$\hat{\sigma}^2_A / \hat{\sigma}^2_D$		1.66	1.14	1.20	1.14
$\sqrt{\hat{\sigma}^2_D / \hat{\sigma}^2_A}$		0.77	0.87	0.91	0.87

***Significant at p=0.05; ** Significant at p= 0.01**
NV= Negative Value

Table 5 :Mean sum of squares, estimates of variance component and their interation with environments for 13 characters of pooled over F_1s (E_1+E_2) and F_2s (E_1+E_2) generations of Indian mustard.

Source of variation	df	Days to flowering		Days to reproductive phase	
		F_1	F_2	F_1	F_2
Environments(E)	1	144.92**	608.47**	338.60**	655.90**
Females (F)	19	77.94**	20.99**	68.07**	72.61**
Males (M)	2	44.71**	157.57**	97.13**	37.53**
F x M	38	32.14**	27.81**	52.72**	46.67**
F x E	19	11.42**	8.74**	21.45**	3.89
M x E	2	2.12	13.73*	15.09*	7.95
F x M x E	38	1.26	2.23	10.43**	6.27*
Error	236	3.98	3.37	4.12	4.83
$\hat{\sigma}^2_f$		1.98	1.98	0.24	0.24
$\hat{\sigma}^2_m$		0.10	0.10	0.33	0.33
$\hat{\sigma}^2_{fm}$		10.29	10.29	14.10	14.10
$\hat{\sigma}^2_{fem}$		1.13	1.13	1.22	1.22
$\hat{\sigma}^2_{men}$		0.01	0.01	0.08	0.08
$\hat{\sigma}^2_{fmen}$		0.27	0.21	0.26	0.35
$\hat{\sigma}^2_g$		3.69	2.12	6.64	5.25
$\hat{\sigma}^2_s$		10.11	10.29	32.40	26.56
$\hat{\sigma}^2_A$		7.38	4.24	13.28	10.50
$\hat{\sigma}^2_D$		10.11	5.15	32.40	13.28
$\hat{\sigma}^2_A/\hat{\sigma}^2_D$		0.73	0.82	0.41	1.26
$\sqrt{\hat{\sigma}^2_D/\hat{\sigma}^2_A}$		1.17	1.10	1.55	1.12

Table 5: Contd.

Source of variation	df	Number of primary branches		Number of secondary branches	
		F_1	F_2	F_1	F_2
Environments(E)	1	602.95**	343.40**	9599.66**	5553.88**
Females (F)	19	14.87**	4.15**	135.19**	70.56**
Males (M)	2	20.70*	21.52**	159.14**	75.27**
F x M	38	14.98**	4.00**	119.38**	24.86**
F x E	19	0.56	3.51**	12.42**	6.84**
M x E	2	1.04	0.24	12.21**	7.95**
F x M x E	38	0.55	0.30	10.80**	2.36
Error	236	1.42	0.79	1.77	1.83
$\hat{\sigma}^2_f$		-0.01	0.01	0.79	2.29
$\hat{\sigma}^2_m$		0.04	0.15	0.32	0.37
$\hat{\sigma}^2_{fm}$		4.81	1.23	36.19	7.50
$\hat{\sigma}^2_{fem}$		0.01	0.01	0.18	0.50
$\hat{\sigma}^2_{men}$		0.01	0.01	0.02	0.09
$\hat{\sigma}^2_{fmen}$		-0.29	-0.16	1.01	0.18
$\hat{\sigma}^2_g$		0.07	0.26	0.76	1.24
$\hat{\sigma}^2_s$		2.04	2.14	2.41	15.35
$\hat{\sigma}^2_A$		0.15	0.51	1.52	2.49
$\hat{\sigma}^2_D$		2.04	1.07	2.41	7.68
$\hat{\sigma}^2_A/\hat{\sigma}^2_D$		0.07	0.24	0.63	0.16
$\sqrt{\hat{\sigma}^2_D/\hat{\sigma}^2_A}$		3.69	2.05	1.26	2.48

Table 5: Contd.

Source of variation	df	Height of plant		Length of main fruiting branch	
		F_1	F_2	F_1	F_2
Environments(E)	1	286.41**	402.19**	138.84**	369.68**
Females (F)	19	1550.54**	512.98**	184.20**	431.94**
Males (M)	2	243.65**	200.11**	208.10**	104.42**
F x M	38	1029.70**	470.86**	258.32**	267.28**
F x E	19	370.98**	197.26**	22.13	102.42**
M x E	2	318.92**	67.97*	10.78	29.6**
F x M x E	38	201.85**	299.92**	34.70*	65.96**
Error	236	18.60	15.86	18.40	4.29
$\hat{\sigma}^2_f$		19.54	19.54	3.42	3.42
$\hat{\sigma}^2_m$		0.03	0.03	0.45	0.45
$\hat{\sigma}^2_{fm}$		275.95	275.95	74.54	74.54
$\hat{\sigma}^2_{fem}$		18.79	18.79	1.40	1.40
$\hat{\sigma}^2_{men}$		1.95	1.95	0.40	0.40
$\hat{\sigma}^2_{fmen}$		4.01	0.70	1.40	2.04
$\hat{\sigma}^2_g$		20.05	17.98	6.80	11.17
$\hat{\sigma}^2_s$		48.20	103.33	42.40	175.33
$\hat{\sigma}^2_A$		40.10	35.95	13.60	22.34
$\hat{\sigma}^2_D$		48.20	51.66	42.40	87.67
$\hat{\sigma}^2_A/\hat{\sigma}^2_D$		0.83	0.69	0.32	0.25
$\sqrt{\hat{\sigma}^2_D/\hat{\sigma}^2_A}$		1.09	1.19	1.77	1.98

Table 5: Contd.

Source of variation	df	Number of siliquae on main fruiting branch		Days to maturity	
		F_1	F_2	F_1	F_2
Environments(E)	1	51504.56**	46285.34**	95.36**	86.54**
Females (F)	19	303.74**	424.62**	111.92**	137.30**
Males (M)	2	416.29**	3.88**	36.03**	253.78**
F x M	38	83.87**	84.16**	73.86**	78.85**
F x E	19	28.85**	39.43**	49.01**	67.50**
M x E	2	36.35**	0.68	14.45**	5.99
F x M x E	38	25.79**	11.40**	20.38**	24.83**
Error	236	5.09	3.33	2.61	2.51
$\hat{\sigma}^2_f$		0.93	15.14	0.52	0.52
$\hat{\sigma}^2_m$		1.02	-0.91	0.27	0.27
$\hat{\sigma}^2_{fm}$		6.03	37.58	17.83	17.83
$\hat{\sigma}^2_{fem}$		0.34	3.11	0.18	0.18
$\hat{\sigma}^2_{men}$		0.18	-0.18	0.10	0.10
$\hat{\sigma}^2_{fmen}$		6.90	2.69	0.30	0.26
$\hat{\sigma}^2_g$		2.01	2.36	0.26	2.20
$\hat{\sigma}^2_s$		30.65	60.56	3.58	7.64
$\hat{\sigma}^2_A$		4.02	4.74	4.52	4.40
$\hat{\sigma}^2_D$		13.65	30.28	3.18	3.82
$\hat{\sigma}^2_A/\hat{\sigma}^2_D$		0.03	0.15	1.42	1.15
$\sqrt{\hat{\sigma}^2_D/\hat{\sigma}^2_A}$		2.77	2.53	0.84	0.93

Table 5: Contd.

Source of variation	df	Relative water content		Leaf water potential	
		F_1	F_2	F_1	F_2
Environments(E)	1	157172.60**	15449.70**	996.00**	1193.00**
Females (F)	19	152.29**	175.79**	71.00**	64.00**
Males (M)	2	17.98**	99.65**	6.00**	116.00**
F x M	38	26.89	19.02**	8.00**	5.00**
F x E	19	16.21**	21.10**	1.00	1.00
M x E	2	3.73	12.96**	1.00	2.00
F x M x E	38	13.21**	12.08**	1.00	1.00
Error	236	1.14	1.42	1.00	2.00
$\hat{\sigma}^2_f$		1.24	2.93	2.00	1.00
$\hat{\sigma}^2_m$		0.83	0.46	1.00	1.00
$\hat{\sigma}^2_{fm}$		37.89	33.98	9.00	27.00
$\hat{\sigma}^2_{fem}$		0.33	1.00	1.00	1.00
$\hat{\sigma}^2_{men}$		-0.16	0.01	1.00	1.00
$\hat{\sigma}^2_{fmen}$		4.03	3.02	1.00	1.00
$\hat{\sigma}^2_g$		2.11	5.14	1.00	1.00
$\hat{\sigma}^2_s$		26.84	46.20	18.00	6.00
$\hat{\sigma}^2_A$		4.23	2.57	2.00	1.00
$\hat{\sigma}^2_D$		26.84	23.01	3.00	3.00
$\hat{\sigma}^2_A/\hat{\sigma}^2_D$		0.16	0.11	66.00	33.00
$\sqrt{\hat{\sigma}^2_D/\hat{\sigma}^2_A}$		2.52	2.99	12.20	17.30

Table 5: Contd.

Source of variation	df	Yield per plant		Oil content	
		F_1	F_2	F_1	F_2
Environments(E)	1	54759.97**	23409.48**	11274.24**	10682.20**
Females (F)	19	1879.53**	93.30**	14.75**	23.41**
Males (M)	2	382.43**	93.30**	14.75**	23.41**
F x M	38	376.31**	275.68**	31.47**	21.85**
F x E	19	154.37**	104.77**	7.62**	2.63**
M x E	2	65.58**	6.43	3.70	40.18**
F x M x E	38	88.10**	20.82**	4.68**	3.16**
Error	236	9.57	3.69	1.09	0.94
$\hat{\sigma}^2_f$		46.50	56.56	0.85	0.01
$\hat{\sigma}^2_m$		-4.76	-1.40	0.13	0.00
$\hat{\sigma}^2_{fm}$		296.07	9.33	0.33	0.06
$\hat{\sigma}^2_{fem}$		7.36	9.33	0.33	0.06
$\hat{\sigma}^2_{men}$		-0.38	-0.24	0.02	0.02
$\hat{\sigma}^2_{fmen}$		6.18	9.17	1.19	0.74
$\hat{\sigma}^2_g$		3.85	12.32	1.25	0.38
$\hat{\sigma}^2_s$		70.49	1.33	20.25	13.94
$\hat{\sigma}^2_A$		7.70	24.64	2.50	0.75
$\hat{\sigma}^2_D$		70.49	99.66	20.25	6.47
$\hat{\sigma}^2_A/\hat{\sigma}^2_D$		0.11	0.25	0.12	0.12
$\sqrt{\hat{\sigma}^2_D/\hat{\sigma}^2_A}$		3.02	2.01	2.85	2.94

Table 5: Contd.

Source of variation	df	Erucic acid	
		F_1	F_2
Environments(E)	1	0.26*	0.20*
Females (F)	19	0.25**	0.26**
Males (M)	2	0.27*	0.19*
F x M	38	0.18**	0.15**
F x E	19	0.09	0.06
M x E	2	0.06	0.21
F x M x E	38	0.01	0.04
Error	236	0.03	0.04
$\hat{\sigma}^2_f$		0.08	0.03
$\hat{\sigma}^2_m$		0.02	0.02
$\hat{\sigma}^2_{fm}$		0.09	0.02
$\hat{\sigma}^2_{fem}$		0.01	0.01
$\hat{\sigma}^2_{men}$		0.01	0.01
$\hat{\sigma}^2_{fmen}$		0.02	0.01
$\hat{\sigma}^2_g$		0.06	0.03
$\hat{\sigma}^2_s$		0.08	0.08
$\hat{\sigma}^2_A$		0.11	0.06
$\hat{\sigma}^2_D$		0.08	0.04
$\hat{\sigma}^2_A/\hat{\sigma}^2_D$		1.37	1.50
$\sqrt{\hat{\sigma}^2_D/\hat{\sigma}^2_A}$		0.85	0.82

***Significant at p=0.05; ** Significant at p=0.0**

Table 6: Estimates of gca effects of lines and testers for 13 characters in both F_1 and F_2 generations in two environments alongwith pooled values in Indian mustard.

S. No.	Parent	Days to flowering					
		Normal Sown (E_1)		Late Sown (E_2)		Pooled (E_1+E_2)	
		F_1	F_2	F_1	F_2	F_1	F_2
	Lines [Females]						
1	**RK 8601**	0.37	-1.05	-1.47**	-1.00*	-0.55	-1.02**
2	**RK8602**	-2.18**	-2.71**	-3.58**	-0.89	-2.88**	-1.80**
3	**RK8604**	-2.40**	6.84	-3.47**	-0.55	-2.94**	0.14
4	**RK8605**	-2.41**	-1.38**	-3.69**	-1.33**	-3.05**	-1.36**
5	**RK8608**	0.04	0.73	-1.69**	0.11	-0.83	0.42
6	**RK8701**	0.15	-0.38	-1.80**	-055	-0.83	-0.46
7	**RK8702**	-0.63	-0.49	-2.25**	-0.78	-1.44	-0.63
8	**RK8801**	-1.40*	0.06	-2.69**	-0.45	-2.05**	-0.19
9	**RK8802**	0.26	-0.27	-1.58**	-0.55	-0.66	-0.41
10	**RK8803**	-0.18	0.84	-1.02*	0.11	0.60	0.48
11	**RK8901**	1.37*	1.84**	2.64**	1.00	2.00**	1.42**
12	**RK8902**	2.37**	0.73	3.64**	0.00	3.01**	0.37
13	**RK8903**	-0.96	1.18*	0.31	-1.55*	-0.33	-0.19
14	**RK9001**	1.15	0.40	2.38**	-0.22	1.76*	0.09
15	**RK9002**	1.15	1.95**	4.09**	1.22**	2.62**	1.59**
16	**RK918506**	1.48*	0.17	2.75**	-0.22	2.12**	-0.02
17	**RK911296**	3.48**	-1.27*	4.75**	-0.89	4.12**	-1.08**
18	**RK 9**	-0.74	-1.05	0.42	1.56**	-0.16	0.26
19	**RK 14**	0.82	-1.82**	2.09**	0.78	1.45	-0.52
20	**KRV 47**	-1.74**	1.62**	0.20	4.23**	-0.77	2.93**
	Testers[Males]						
21	**Mathura Rai**	0.82**	-0.91**	0.58**	-0.41**	0.70**	-0.66**
22	**Laha 101**	-0.37	1.71**	-0.43**	0.94**	-0.40	1.32**
23	**Vaibhav**	-0.45*	-0.79**	-0.15	-0.53**	-0.30	-0.66**
	SE($\hat{g}_{if}$)	0.67	0.54	0.51	0.47	0.73	0.36
	SE($\hat{g}_{im}$)	0.21	0.18	0.16	0.15	0.24	0.12

Table 6: Contd.

S. No.	Parent	Days to reproductive phase					
		Normal Sown (E_1)		Late Sown (E_2)		Pooled (E_1+E_2)	
		F_1	F_2	F_1	F_2	F_1	F_2
	Lines [Females]						
1	**RK 8601**	0.44	0.27	-0.35	0.07	0.04	0.17
2	**RK8602**	-2.90**	3.38**	-2.46**	2.07**	-2.68**	2.72**
3	**RK8604**	-4.23**	-1.73	-3.24**	-1.15**	-3.73**	-1.44**
4	**RK8605**	-4.79**	-3.07**	-3.79**	-1.38**	-4.29**	-2.22**
5	**RK8608**	1.77**	3.93**	0.87	2.74**	1.32**	3.34**
6	**RK8701**	-1.39	-2.51**	2.66	-3.15**	0.63	-2.83**
7	**RK8702**	-0.01	1.82	-0.57	1.18**	-0.29	1.50**
8	**RK8801**	0.55	-1.62	-0.24	-1.15**	0.15	-1.39**
9	**RK8802**	2.32**	-3.95**	0.76	-2.71**	1.54**	-3.33**
10	**RK8803**	-3.90**	0.94	2.20**	0.63*	-0.85*	0.78
11	**RK8901**	-0.68	0.71	2.32**	0.51	0.82*	0.61
12	**RK8902**	-1.33	0.71	0.30	0.40	0.81*	0.56
13	**RK8903**	1.54*	-3.06**	0.44	-1.93**	0.99*	-2.50**
14	**RK9001**	4.55**	3.26**	1.21**	1.96**	2.88**	2.61**
15	**RK9002**	-1.34	-1.84	-1.35**	-1.27**	-1.35**	-1.56**
16	**RK918506**	-1.34	0.37	-1.80**	1.62**	-1.57**	1.00
17	**RK911296**	2.77**	2.82**	1.43**	1.85**	2.10**	2.33**
18	**RK 9**	3.21**	-1.95	1.43**	-1.15**	2.32**	-1.55**
19	**RK 14**	2.21**	1.82	0.76*	1.07**	1.49**	1.44**
20	**KRV 47**	-0.12	-0.29	-0.57	-0.22	-0.35	-0.25
	Testers[Males]						
21	**Mathura Rai**	-1.22**	0.79*	-0.65**	0.22**	-0.93**	0.50**
22	**Laha 101**	-0.04	-0.01	0.18	0.20*	0.07	0.10
23	**Vaibhav**	1.26**	-0.79*	0.47**	0.41**	0.86**	-0.60**
	SE($\hat{g}_{if}$)	0.71	0.98	0.36	0.30	0.40	0.51
	SE($\hat{g}_{im}$)	0.23	0.32	0.12	0.10	0.13	0.17

Table 6: Contd.

		Number of primary branches					
S. No.	Parent	Normal Sown (E_1)		Late Sown (E_2)		Pooled (E_1+E_2)	
		F_1	F_2	F_1	F_2	F_1	F_2
	Lines [Females]						
1	**RK 8601**	0.46	0.25	0.23	0.06	0.35	0.15
2	**RK8602**	-2.8**	3.66**	-1.88**	2.06**	-2.38**	2.71**
3	**RK8604**	-4.21**	-1.75	-2.66**	-1.17**	-3.43**	-1.16**
4	**RK8605**	-4.76**	-3.08	-3.21**	-2.17**	-3.99**	-2.62**
5	**RK8608**	1.79**	4.03**	1.12**	2.50**	1.46**	3.26**
6	**RK8701**	-1.32**	-2.53	-0.77**	-1.75**	-1.04**	-2.12**
7	**RK8702**	0.02	1.81**	0.01	1.71**	0.01	1.49**
8	**RK8801**	0.57	-1.64**	0.34	-1.71**	0.46	-1.40**
9	**RK8802**	2.35**	-3.97**	1.46**	-2.72**	1.90**	-3.35**
10	**RK8803**	-3.87**	0.92**	-2.54**	0.61**	-3.21**	0.76**
11	**RK8901**	-0.65	0.69	-0.43	0.50*	-0.54*	0.60**
12	**RK8902**	1.35**	0.69	0.90**	0.39	1.12**	0.54**
13	**RK8903**	1.57**	-3.08**	1.01**	-1.94**	1.29**	-2.51**
14	**RK9001**	4.57**	3.25**	2.90**	1.94**	3.74**	2.60**
15	**RK9002**	-1.32**	-1.86**	-0.77**	-2.28**	-1.04**	-1.57**
16	**RK918506**	-1.98**	0.58	-1.21**	1.61**	-1.60**	1.01**
17	**RK911296**	2.91**	2.81**	2.01**	1.83**	2.46**	2.32**
18	**RK 9**	3.24**	-1.97**	2.01**	-1.28**	2.62**	-1.62**
19	**RK 14**	2.24**	1.81**	1.46**	1.06**	1.85**	1.73**
20	**KRV 47**	-0.09	-0.31	0.01	-0.28	-0.04	-0.29
	Testers[Males]						
21	**Mathura Rai**	-1.18**	0.79**	-0.85**	0.47**	-1.01**	0.63**
22	**Laha 101**	-0.11	-0.02	-0.04	0.17**	-0.10	-0.07
23	**Vaibhav**	1.29**	-0.77**	0.93**	-0.63**	1.11**	-0.70**
	SE($\hat{g}_{if}$)	0.39	0.37	0.27	0.21	0.24	0.21
	SE($\hat{g}_{im}$)	0.13	0.12	0.09	0.07	0.08	0.07

Table 6: Contd.

S. No.	Parent	Number of secondary branches					
		Normal Sown (E_1)		Late Sown (E_2)		Pooled (E_1+E_2)	
		F_1	F_2	F_1	F_2	F_1	F_2
	Lines [Females]						
1	**RK 8601**	0.14	-0.89**	0.13	-0.57**	0.13	-0.73**
2	**RK8602**	0.36	-0.01	0.28	0.05	0.32*	0.02
3	**RK8604**	0.96**	-0.23	0.52*	-0.05	0.61**	-0.44**
4	**RK8605**	1.19**	0.66**	-0.81**	0.51*	-1.00**	0.59**
5	**RK8608**	-0.08	1.22**	-0.03	0.36	-0.06	0.79**
6	**RK8701**	-0.42	0.11	-0.26	0.13	-0.34*	0.12
7	**RK8702**	-0.97**	-0.01	-0.65**	0.05	-0.81**	0.02
8	**RK8801**	-1.42**	0.22	-0.99**	0.20	-1.21**	0.21
9	**RK8802**	-0.42	-0.45	-0.26	-0.26	-0.34*	-0.36**
10	**RK8803**	-0.97**	0.11	-0.66**	0.13	-0.82**	0.12
11	**RK8901**	-0.86*	0.22	-0.91**	0.20	-0.88**	0.21
12	**RK8902**	-0.86*	1.22**	-0.57*	0.88**	-0.72**	1.05**
13	**RK8903**	0.47	-0.12	0.36	0.05	0.42**	-0.03
14	**RK9001**	2.03**	-0.78**	1.14**	-0.50*	1.58**	-0.64**
15	**RK9002**	1.14**	-0.56*	0.83**	-0.34	0.98**	-0.45**
16	**RK918506**	1.69**	-0.78**	1.22**	-0.50*	1.46**	-0.64**
17	**RK911296**	-0.53	-0.01	-0.25	0.05	-0.39**	0.02
18	**RK 9**	-1.42**	-0.12	-0.96**	-0.03	-1.19**	-0.04
19	**RK 14**	1.47**	0.55**	1.06**	0.44*	1.27**	0.49**
20	**KRV 47**	1.14**	-0.34	0.83**	-0.19	0.98**	0.26
	Testers[Males]						
21	**Mathura Rai**	0.01	0.51**	-0.01	0.41**	0.00	0.46**
22	**Laha 101**	0.51**	-0.41**	0.33**	-0.34**	0.42**	-0.37**
23	**Vaibhav**	-0.51**	-0.11	-0.31**	-0.07	-0.41**	-0.09
	SE($\hat{g}_{if}$)	0.38	0.27	0.26	0.22	0.23	0.17
	SE($\hat{g}_{im}$)	0.12	0.09	0.09	0.07	0.08	0.06

Table 6: Contd.

S. No.	Parent	Height of plant					
		Normal Sown (E_1)		Late Sown (E_2)		Pooled (E_1+E_2)	
		F_1	F_2	F_1	F_2	F_1	F_2
	Lines [Females]						
1	**RK 8601**	-22.13**	-12.24**	-26.31**	-11.25**	-24.22**	-11.74**
2	**RK8602**	-0.46	3.65*	-10.42**	9.20**	-5.44**	6.42**
3	**RK8604**	3.31*	5.21**	-2.54**	1.87**	0.39	3.54**
4	**RK8605**	-5.58**	-2.02	-8.86**	-10.14**	-7.22**	-6.08**
5	**RK8608**	3.65**	2.54	0.84*	7.64**	2.25**	5.09**
6	**RK8701**	6.65**	2.32	2.47**	-1.83*	4.56**	0.65
7	**RK8702**	-3.79*	-6.46**	-7.86**	-8.69**	-5.83**	-7.57**
8	**RK8801**	4.31**	6.87**	-4.53**	-1.81**	-0.11	2.53**
9	**RK8802**	1.87	5.21**	6.47**	-1.72**	4.17**	1.74*
10	**RK8803**	7.42**	0.65	0.58	-3.02**	4.00**	-1.18
11	**RK8901**	3.87**	-0.35	-4.53**	2.64**	-0.33	1.15
12	**RK8902**	-2.57	-4.57**	-11.86**	11.53**	-7.22**	3.48**
13	**RK8903**	-11.13**	2.65	-13.20**	-5.13**	-12.16**	-1.24
14	**RK9001**	-6.24**	-3.02*	-7.20**	-4.58**	-6.72**	-3.80**
15	**RK9002**	0.09	1.32	7.47**	11.89**	3.78**	6.20**
16	**RK918506**	9.31**	-8.13**	12.92**	-4.58**	11.11**	-6.35**
17	**RK911296**	2.09	4.54**	13.36**	3.42**	7.73**	3.98**
18	**RK 9**	3.87*	4.09**	11.14**	13.08**	7.50**	8.59**
19	**RK 14**	5.42**	-3.46*	32.03**	-5.14**	15.72**	-4.30
20	**KRV 47**	0.05	1.18	10.03**	-3.36**	5.04**	-1.09
	Testers[Males]						
21	**Mathura Rai**	0.06	0.55	-1.19**	2.29**	-0.56	1.42**
22	**Laha 101**	4.55**	-1.32**	2.11**	-2.09**	3.33**	-1.70**
23	**Vaibhav**	-4.62**	0.76	-0.92**	-0.20	-2.77	0.28
	SE($\hat{g}_{if}$)	1.63	1.48	0.42	0.48	0.84	0.78
	SE($\hat{g}_{im}$)	0.53	0.48	0.14	0.16	0.27	0.25

Table 6: Contd.

S. No.	Parent	Length of main fruiting branch					
		Normal Sown (E_1)		Late Sown (E_2)		Pooled (E_1+E_2)	
		F_1	F_2	F_1	F_2	F_1	F_2
	Lines [Females]						
1	**RK 8601**	-1.00	-1.26*	-0.99	1.33*	-0.99	0.64
2	**RK8602**	-1.99	-4.48**	-0.88	3.66**	-1.43	-0.41
3	**RK8604**	3.12**	-0.16	0.90	-0.56	2.01*	-0.36
4	**RK8605**	-2.33	4.96**	-1.43	1.88**	-1.88*	3.42**
5	**RK8608**	8.01**	6.19**	3.23**	-0.67	5.62**	2.76**
6	**RK8701**	3.67**	9.74**	2.41*	3.88**	3.04**	6.81**
7	**RK8702**	2.67*	4.85**	1.46	4.78**	2.07*	4.82**
8	**RK8801**	5.00**	0.08	3.46**	-0.22	4.23**	-0.07
9	**RK8802**	1.67	0.08	1.57	1.22*	1.62	0.65
10	**RK8803**	2.67*	-8.70**	1.25	-4.34**	1.96*	-6.52**
11	**RK8901**	4.45**	18.63**	1.90	5.44**	3.18**	12.04**
12	**RK8902**	-2.99*	1.52**	-2.77*	0.44	-2.88**	0.98*
13	**RK8903**	-2.99*	1.63**	-1.54	1.00	-2.27**	1.31**
14	**RK9001**	-3.11**	-3.93**	-1.88	-2.22**	-2.49**	-3.07**
15	**RK9002**	-7.77**	-3.70**	-3.88**	-2.00**	-5.82**	-2.85**
16	**RK918506**	1.67	-4.60**	4.23**	-4.11**	2.95**	-4.36**
17	**RK911296**	-0.88	0.29	-1.66	-0.17	-1.27	0.06
18	**RK 9**	-1.77	-7.70**	-1.32	-4.11**	-1.55	-5.91**
19	**RK 14**	-8.55**	0.41	-3.76**	1.33*	-6.16**	0.87*
20	**KRV 47**	0.45	13.81**	-0.32	-6.58**	0.06	-10.20**
	Testers[Males]						
21	**Mathura Rai**	-0.44**	-0.96**	-0.34	-0.79**	-0.39	-0.88**
22	**Laha 101**	2.03**	-2.49**	-1.38**	-1.59**	1.71**	-2.04**
23	**Vaibhav**	-1.59**	3.44**	-1.05**	2.38**	-1.32**	2.91**
	SE($\hat{g}_{if}$)	1.23	0.57	1.14	0.58	0.84	0.40
	SE($\hat{g}_{im}$)	0.04	0.18	0.37	0.19	0.27	0.13

Table 6: Contd.

		Number of siliquae on main fruiting branch					
S. No.	Parent	Normal Sown (E_1)		Late Sown (E_2)		Pooled (E_1+E_2)	
		F_1	F_2	F_1	F_2	F_1	F_2
	Lines [Females]						
1	**RK 8601**	-2.06*	-2.08	-0.99*	-0.46	-1.52**	-1.17
2	**RK8602**	-1.94*	-5.31**	-0.88*	-1.90**	1.41**	-3.60**
3	**RK8604**	2.06*	-1.08	0.90*	-0.12	1.48**	-0.60
4	**RK8605**	-3.39**	4.03	-1.43**	2.32**	-2.41**	3.18**
5	**RK8608**	7.17**	-1.31	-3.23**	-0.23	5.20**	-0.77
6	**RK8701**	5.28**	8.92**	2.34**	4.32**	3.81**	6.62**
7	**RK8702**	3.28**	10.69**	1.46**	5.21**	2.37**	7.95**
8	**RK8801**	7.94**	-0.75	3.46**	0.21	5.70**	-0.27
9	**RK8802**	3.28**	2.58	1.46**	1.66**	2.37**	2.12
10	**RK8803**	2.61**	-12.86**	1.23**	-3.79**	1.92**	-8.32**
11	**RK8901**	4.39**	34.47**	2.12**	5.88**	3.26**	20.18**
12	**RK8902**	-6.06**	0.69	-2.77**	0.88**	-4.41**	0.79
13	**RK8903**	-3.83**	0.81	-1.54**	0.88**	-2.69**	0.84
14	**RK9001**	-4.17**	-4.75*	-1.88**	-1.79**	-3.02**	-3.27**
15	**RK9002**	-8.83**	-4.53	-3.88	-1.57**	-6.36**	-3.05**
16	**RK918506**	9.61**	-8.75**	4.23**	-3.68**	6.92**	-6.21**
17	**RK911296**	-3.61**	-0.53	-1.66**	0.10	-2.63**	-0.21
18	**RK 9**	-2.83**	-8.53**	-1.32**	-3.68**	-2.08**	-6.10**
19	**RK 14**	-8.28**	2.92	-3.77**	1.77**	-6.02**	2.34
20	**KRV 47**	-0.61	-14.64**	-0.32	-6.01**	-0.47	-10.32**
	Testers[Males]						
21	**Mathura Rai**	-0.77**	-1.81*	-0.32**	-0.35**	-0.54**	-1.08**
22	**Laha 101**	3.13**	-2.31**	1.37**	-2.13**	2.25**	-2.22**
23	**Vaibhav**	-2.37**	4.12**	-1.05**	2.48**	-1.71**	3.30**
	SE($\hat{g}_{if}$)	0.86	2.36	0.40	0.31	0.47	1.19
	SE($\hat{g}_{im}$)	0.28	0.77	0.13	0.10	0.15	0.39

Table 6: Contd.

S. No.	Parent	Days to maturity					
		Normal Sown (E_1)		Late Sown (E_2)		Pooled (E_1+E_2)	
		F_1	F_2	F_1	F_2	F_1	F_2
	Lines [Females]						
1	**RK 8601**	-0.65	8.48**	-0.80	-1.31*	-0.73	3.59**
2	**RK8602**	-4.97**	10.59**	1.88**	-0.42	-1.55**	5.09**
3	**RK8604**	-6.53**	9.03**	1.09	-2.42**	-2.72**	3.31**
4	**RK8605**	-7.09**	5.46**	-6.46**	-3.09**	-6.78**	1.19**
5	**RK8608**	1.91**	14.81**	-0.13	2.47**	0.89	8.64**
6	**RK8701**	-0.98	6.81**	1.87**	-2.97**	0.44	1.92**
7	**RK8702**	-0.53	11.25**	-1.80**	0.03	-1.17**	5.64**
8	**RK8801**	-1.42*	8.35**	-1.91**	-0.97	-1.66**	3.69**
9	**RK8802**	2.69**	5.68**	0.31	0.14	1.50**	2.91**
10	**RK8803**	-3.97**	11.69**	1.31*	0.36	-1.33**	6.03**
11	**RK8901**	0.69	12.48**	2.53**	1.14*	1.61**	6.81**
12	**RK8902**	3.80**	11.36**	0.74	0.03	2.27**	5.70**
13	**RK8903**	0.69	-17.97**	-1.02	4.03**	-0.17	-6.97**
14	**RK9001**	5.80**	-12.75**	2.31**	1.36*	4.06**	-5.69**
15	**RK9002**	1.58*	-14.53**	-0.13	-0.42	0.73	-7.47**
16	**RK918506**	0.69	13.08**	-1.58*	1.02	-0.44	-6.03**
17	**RK911296**	6.47**	-14.41**	3.20**	-0.31	4.84**	-7.36**
18	**RK 9**	2.47**	-14.19**	0.09	1.03	1.28**	-6.58**
19	**RK 14**	0.44	-14.98**	0.65	0.25	0.54	-7.37**
20	**KRV 47**	-1.09	14.08**	-2.14**	0.03	-1.61**	-7.03**
	Testers[Males]						
21	**Mathura Rai**	0.53*	0.15	0.43*	0.18	0.48**	0.02
22	**Laha 101**	-0.44*	1.71**	0.17	1.18**	-0.13	1.45**
23	**Vaibhav**	0.97**	-1.57**	0.26	-1.36**	0.61**	-1.46**
	SE($\hat{g}_{if}$)	0.66	0.28	0.65	0.55	0.46	0.31
	SE($\hat{g}_{im}$)	0.22	0.09	0.21	0.18	0.15	0.10

Table 6: Contd.

S. No.	Parent	Relative water content					
		Normal Sown (E_1)		Late Sown (E_2)		Pooled (E_1+E_2)	
		F_1	F_2	F_1	F_2	F_1	F_2
	Lines [Females]						
1	**RK 8601**	15.36**	4.82**	8.91**	2.61**	12.13**	3.71**
2	**RK8602**	6.80**	5.37**	4.13**	3.17**	5.47**	4.27**
3	**RK8604**	4.24**	6.93**	2.29*	4.06**	3.47**	5.49**
4	**RK8605**	-5.42**	-2.07**	-2.64**	-1.17**	-4.03**	-1.62**
5	**RK8608**	2.24**	-3.18**	-3.20**	-1.83**	-0.48	-2.51**
6	**RK8701**	10.58**	26.04**	6.13**	14.72**	8.36**	20.38**
7	**RK8702**	25.13**	14.71**	14.58**	8.39**	19.86**	11.55**
8	**RK8801**	7.13**	17.15**	4.36**	9.72**	5.74**	13.44**
9	**RK8802**	-7.20**	-1.63**	-3.87**	-0.83*	-5.53**	-1.23**
10	**RK8803**	-12.53**	-3.07**	-6.87**	-1.72**	-9.70**	-2.40**
11	**RK8901**	-3.31**	1.59*	-1.64	1.06**	-2.48**	1.30**
12	**RK8902**	-11.98**	13.82**	-6.53**	7.72**	-9.26**	10.77**
13	**RK8903**	-11.98**	-4.29**	-6.64**	-2.50**	-9.31**	-3.40**
14	**RK9001**	24.58**	-9.41**	3.80**	-5.50**	19.19**	-7.45**
15	**RK9002**	15.69**	-9.63**	9.02**	5.17**	12.36**	-7.40**
16	**RK918506**	-5.64**	-10.63**	-2.98**	-5.94**	-4.21**	-8.29**
17	**RK911296**	-11.42**	-10.85**	-6.31**	-6.28**	-8.87**	-8.56**
18	**RK 9**	-12.31**	-12.07**	-6.64**	-6.94**	-9.48**	-9.51**
19	**RK 14**	-13.42**	-13.18**	-7.31**	-2.50**	-10.37**	-10.34**
20	**KRV 47**	-16.53**	-10.41**	-8.98**	-6.06**	-12.76**	-8.23**
	Testers[Males]						
21	**Mathura Rai**	0.11	0.29	0.23	0.22	0.17	0.25*
22	**Laha 101**	2.46**	-1.23**	0.93**	-0.73**	1.69**	-0.98**
23	**Vaibhav**	-2.57**	0.94**	-1.16**	0.52**	-1.86**	0.73**
	SE($\hat{g}_{if}$)	0.77	0.64	0.93	0.39	0.60	0.38
	SE($\hat{g}_{im}$)	0.25	0.21	0.30	0.13	0.20	0.12

Table 6: Contd.

S. No.	Parent	Leaf water potential					
		Normal Sown (E_1)		Late Sown (E_2)		Pooled (E_1+E_2)	
		F_1	F_2	F_1	F_2	F_1	F_2
	Lines [Females]						
1	**RK 8601**	4.89**	2.22**	2.37**	1.09**	3.63**	1.66**
2	**RK8602**	1.99**	-3.98**	1.01**	-1.79**	1.50**	-2.88**
3	**RK8604**	0.58	-0.18	0.35	-0.02	0.46*	-0.10
4	**RK8605**	1.78**	0.27	0.91**	0.03	1.34**	0.15
5	**RK8608**	-0.71*	-0.23	-0.29	-0.15	-0.50**	-0.19
6	**RK8701**	-0.32	0.70*	-0.07	0.39	-0.19	0.55**
7	**RK8702**	-1.53**	1.48**	0.80**	0.76**	1.17**	1.12**
8	**RK8801**	-0.91**	0.09	0.56**	0.10	-0.73**	0.10
9	**RK8802**	-1.03**	0.76**	-0.73**	0.42	-0.88**	0.59**
10	**RK8803**	0.02	0.48	0.10	0.29	-0.06	0.38*
11	**RK8901**	0.95**	-0.38	0.53**	-0.11	0.74**	-0.24
12	**RK8902**	2.27**	0.46	1.14**	0.28	1.71**	0.37
13	**RK8903**	2.53**	1.09**	0.15	0.37*	1.34**	0.83**
14	**RK9001**	1.42**	0.97**	0.74**	0.52*	1.08**	0.74**
15	**RK9002**	-1.24**	-1.89**	-0.49*	-082**	-0.86**	-1.36**
16	**RK918506**	-2.18**	0.31	-0.93**	0.21	-1.56**	0.26
17	**RK911296**	-2.41**	-0.50	-1.04**	-0.17	-1.72**	-0.33
18	**RK 9**	-1.90**	-2.24**	-0.80**	-0.98**	-1.35**	-1.61**
19	**RK 14**	-5.56**	1.03**	-2.50**	0.55*	-4.03**	0.79**
20	**KRV 47**	-1.69**	-0.48	-0.70**	-1.18**	-1.19**	-0.83
	Testers[Males]						
21	**Mathura Rai**	0.34**	0.37**	0.16*	0.24**	0.25**	0.30**
22	**Laha 101**	-0.60**	0.34**	-0.19**	0.05	-0.40**	0.20**
23	**Vaibhav**	0.28*	-0.72**	0.04	-0.29**	0.15*	-0.50**
	SE($\hat{g}_{if}$)	0.35	0.29	0.21	0.24	0.28	0.19
	SE($\hat{g}_{im}$)	0.11	0.10	0.07	0.08	0.07	0.06

Table 6: Contd.

S. No.	Parent	Yield per plant					
		Normal Sown (E_1)		Late Sown (E_2)		Pooled (E_1+E_2)	
		F_1	F_2	F_1	F_2	F_1	F_2
	Lines [Females]						
1	**RK 8601**	0.27	-1.19	0.14	-0.68*	0.20	-0.94**
2	**RK8602**	0.39	-8.37**	0.20	-4.35**	0.30	-6.36**
3	**RK8604**	1.49**	2.50**	0.76**	1.17**	1.12**	1.83**
4	**RK8605**	-5.42**	-2.79**	-2.76	-1.54**	-4.09**	-2.17**
5	**RK8608**	-0.02	4.05**	-0.02	1.98**	-0.02	3.02**
6	**RK8701**	1.58**	5.41**	0.81**	2.67**	1.20**	4.04**
7	**RK8702**	6.29**	5.08**	3.23**	2.49**	4.76**	3.79**
8	**RK8801**	2.16**	-1.89**	1.10**	-0.99**	1.63**	-1.44**
9	**RK8802**	-4.48**	1.93**	-2.29	0.89**	3.38**	1.41**
10	**RK8803**	0.41	0.61	0.21	0.26	0.31	0.43
11	**RK8901**	4.02**	-3.67**	2.05**	-0.26	3.84**	-1.97**
12	**RK8902**	6.69**	0.60	3.41**	0.22	5.05**	0.41
13	**RK8903**	-2.74**	-6.06**	-1.39	-3.19**	-2.06**	-4.63**
14	**RK9001**	-1.60**	5.16**	-0.81	2.55**	-1.20**	3.86**
15	**RK9002**	1.36**	-3.19**	0.67**	-1.72**	1.01**	-2.46**
16	**RK918506**	-4.73**	-6.03**	-2.42	-3.15**	3.58**	-4.59**
17	**RK911296**	-4.21**	2.96**	-2.15	1.43**	-3.18**	2.19**
18	**RK 9**	-4.64**	-2.26	-2.36	-1.25**	3.50**	-1.76**
19	**RK 14**	-3.09**	5.12**	-1.59	2.52**	-2.34**	3.82**
20	**KRV 47**	6.26**	2.06**	3.19**	0.95**	4.72**	-1.51**
	Testers[Males]						
21	**Mathura Rai**	-0.60**	0.72**	-0.31**	0.29**	-0.45**	0.50**
22	**Laha 101**	0.25*	-1.18**	0.13*	-0.44	0.19**	-0.81**
23	**Vaibhav**	0.34**	0.45*	0.18**	0.15	0.26**	-0.30**
	SE($\hat{g}_{if}$)	0.37	0.60	0.19	0.31	0.21	0.34
	SE($\hat{g}_{im}$)	0.12	0.20	0.06	0.10	0.07	0.01

Table 6:

		Oil content					
S. No.	Parent	Normal Sown (E_1)		Late Sown (E_2)		Pooled (E_1+E_2)	
		F_1	F_2	F_1	F_2	F_1	F_2
	Lines [Females]						
1	**RK 8601**	0.01	-0.17**	-0.01	-0.21**	0.01	-0.19**
2	**RK8602**	0.05	0.21**	0.07**	0.27**	0.06**	0.04
3	**RK8604**	0.05	0.09**	0.06*	0.12**	0.05**	0.11**
4	**RK8605**	0.08**	0.10**	0.10**	0.14**	0.09**	0.12**
5	**RK8608**	0.04	-0.10**	0.05	-0.12**	0.05**	-0.11**
6	**RK8701**	0.21**	-0.05	0.27**	-0.05	0.24**	-0.05
7	**RK8702**	0.02	- 0.06*	0.11**	-0.07	0.27**	-0.07**
8	**RK8801**	-0.29**	-0.05	-0.37**	-0.06	-0.33**	-0.06*
9	**RK8802**	-0.01	0.01	-0.01	0.01	-0.01	0.01
10	**RK8803**	-0.12**	0.26**	-0.16**	0.33**	-0.14**	0.29**
11	**RK8901**	0.47**	0.05	0.59**	0.07	0.53**	0.06*
12	**RK8902**	-0.14**	0.29**	-0.17*	-0.36**	-0.15**	-0.32**
13	**RK8903**	0.19**	-0.18**	0.24**	-0.22**	0.21**	-0.20**
14	**RK9001**	0.17**	0.16**	0.17**	0.19**	0.17**	0.18**
15	**RK9002**	-0.02	0.35**	-0.02	0.46**	-0.02	0.41**
16	**RK918506**	-0.05	-0.03	-0.07**	-0.03	-0.06**	-0.03
17	**RK911296**	-0.19**	0.10**	-6.24**0	0.13**	-0.21**	0.12**
18	**RK 9**	-0.07*	-0.23**	-0.09**	-0.28**	-0.08**	-0.25**
19	**RK 14**	-0.22	-0.13**	-0.28	-0.23**	-0.25**	-0.18**
20	**KRV 47**	-0.18**	-0.05	-0.23	-0.08*	-0.20**	-0.06*
	Testers[Males]						
21	**Mathura Rai**	0.01	0.01	-0.01	0.01	-0.01	0.01
22	**Laha 101**	-0.01	-0.09**	-0.03**	-0.11**	-0.02*	-0.10
23	**Vaibhav**	0.02*	0.08**	0.03**	0.11**	0.03**	-0.10
	SE($\hat{g}_{if}$)	0.03	0.03	0.03	0.04	0.02	0.03
	SE($\hat{g}_{im}$)	0.01	0.01	0.01	0.01	0.01	0.03

Table 6: Contd.

S. No.	Parent	Erucic acid					
		Normal Sown (E_1)		Late Sown (E_2)		Pooled (E_1+E_2)	
		F_1	F_2	F_1	F_2	F_1	F_2
	Lines [Females]						
1	**RK 8601**	0.30	-0.39	0.89**	0.10	0.60	-0.15
2	**RK8602**	1.61**	-0.38	1.10**	-0.11	0.85**	-0.24
3	**RK8604**	0.68*	-0.38	-0.13	0.10	-0.02	-0.14
4	**RK8605**	-0.28	0.94*	-0.02	-0.21	-0.15	-0.04
5	**RK8608**	0.09	-0.07	0.31	0.10	0.20	0.02
6	**RK8701**	-0.22	-0.07	0.56*	-0.11	0.17	-0.09
7	**RK8702**	0.09	-0.07	0.97**	0.10	0.53	0.02
8	**RK8801**	-1.19*	-1.07**	-1.05**	0.01	-1.48*	-1.18*
9	**RK8802**	-0.14	-0.27	1.08**	0.10	0.97	-0.09
10	**RK8803**	0.20	-0.27	-0.13	-0.11	0.03	-0.19
11	**RK8901**	-0.22	-0.17	-0.82**	0.44*	-0.52	1.14
12	**RK8902**	-0.01	-0.27	0.18	-0.11	1.08	-0.19
13	**RK8903**	-1.11*	-1.36**	-0.95**	-9.12**	-1.13*	-1.21*
14	**RK9001**	-1.22**	1.14**	-0.96*	-1.21**	-1.11*	-1.14
15	**RK9002**	-0.11*	0.23	0.08	0.10	-0.02	0.16
16	**RK918506**	-0.22	1.24**	-0.05	1.10**	-0.13	0.17
17	**RK911296**	1.09	-0.07	-0.38	-0.01	-0.15	-0.04
18	**RK 9**	1.09	-0.07	-0.41	-0.11	-0.16	-0.09
19	**RK 14**	0.09	0.47*	-0.77**	-0.01	-0.34	0.23
20	**KRV 47**	-0.11	0.04	-0.07	-0.01	-0.09	1.02
	Testers[Males]						
21	**Mathura Rai**	0.04	-0.06	-0.21	0.04	-0.09	0.01
22	**Laha 101**	-0.08	-0.07	0.07	0.02	0.00	0.02
23	**Vaibhav**	0.04	0.13	0.14	-0.06	0.09	0.04
	SE($\hat{g}_{if}$)	0.28	0.23	0.24	0.21	0.30	0.29
	SE($\hat{g}_{im}$)	0.12	0.07	0.15	0.26	0.10	0.14

***Significant at p=0.05; **Significant at p=0.01**

Table 7: Estimates of sca effects of F_1 and F_2 crosses for 13 characters in two environments alongwith pooled values in Indian mustard.

S. No.	Crosses	Days to flowering					
		Normal Sown(E_1)		Late Sown(E_2)		Pooled	
		F_1	F_2	F_1	F_2	F_1	F_2
1	RK 8601x M. Rai	2.96**	-0.42	2.31**	-0.70	2.64**	-0.56
2	RK8602 x M. Rai	-0.19	2.29**	0.02	1..95**	0.11	2.12**
3	RK8604 x M. Rai	2.77 *	-1.87*	-2.29**	-1.25	-2.53**	1.56**
4	RK8605 x M. Rai	-1.15	-1.09	-0.58	1..52*	0.87	0.22
5	RK8608 x M. Rai	-0.30	0.29	0.43	-0.83	0.07	-0.27
6	RK8701 x M. Rai	1.45	0.79	0.15	-0.69	0.80	0.05
7	RK8702 x M. Rai	-0.93	-4.98**	-1.03	-2-81**	-0.98	-3.90**
8	RK8801 x M. Rai	-0.08	2.07**	0.32	2.51**	0.12	2.29**
9	RK8802 x M. Rai	1.01	2.90**	0.71	0.30	0.86	1.60**
10	RK8803 x M. Rai	0.74	-0.09	0.53	-0.36	0.64	-0.23
11	RK8901 x M. Rai	-1.41	0.62	0.80	0.95	-1.11	0.79
12	RK8902 x M. Rai	0.67	-0.54	0.27	-0.59	0.47	-0.56
13	RK8903 x M. Rai	-1.37	-1.53	-1.14	-1.15	-1.25	-1.34**
14	RK9001 x M. Rai	4.14**	0.52	3.21**	0.50	3.67**	0.51
15	RK9002 x M. Rai	-2.77*	1.01	-2.07**	0.64	-2.42*	0.83
16	RK918506 x M. Rai	0.19	-1.42	0.30	-1.14	0.24	-1.23*
17	RK 911296 x M.Rai	-1.97*	-3.04**	-1.34	-2.16**	-1.66	-2.60**
18	RK 9 x M. Rai	1.78	4.46**	1.04	3.30**	1.41	3.88**
19	RK 14 x M. Rai	-0.38	-0.31	-0.25	-0.26	-0.32	-0.28
20	KRV 47 x M. Rai	0.15	2.73**	0.10	2.06	0.12	2.40**
21	RK8601 x Laha 101	0.23	-2.43**	0.15	-1.80**	0.19	-2.11**
22	RK8602 x Laha 101	-1.93*	-0.53	-1.47*	-0.59	-1.70	-0.56
23	RK 8604 x Laha 101	3.92**	0.85	2.87**	1.06	3.40**	0.96
24	RK8605 x Laha 101	-1.99*	-0.32	-1.40	-0.47	-1.70	-0.56
25	RK8608 x Laha 101	-2.92**	0.13	-2.25**	-0.14	-2.59**	-0.01
26	RK8701 x Laha 101	1.92*	-0.82	1.76*	-0.16	1.84	-0.49
27	RK8702 x Laha 101	1.00	0.68	0.49	0.30	0.75	0.49
28	RK8801x Laha 101	1.18	0.69	0.19	-0.48	-0.69	0.10
29	RK8802 x Laha 101	-0.30	0.07	-1.12	0.84	-0.71	0.46
30	RK8803 x Laha 101	-0.88	-0.76	0.93	-0.36	0.02	0.56
31	RK 8901 x Laha 101	0.63	1.02	0.86	0.63	0.74	0.83
32	RK 8902 x Laha 101	-0.52	1.74*	-0.46	1.28	-0.49	1.51**
33	RK 8903 x Laha 101	-0.11	-2.76**	-0.40	-1.92**	-0.25	-2.34**
34	RK 9001 x Laha 101	3.62**	-0.53	3.86**	-1.04	3.74**	-0.78
35	RK 9002 x Laha 101	-1.85	1.51	-1.79*	1.61*	-1.82	1.58**
36	RK 918506x Laha 101	-1.77	-0.99	-2.07**	-0.58	-1.92	-0.78
37	RK911296 x Laha 101	1.30	2.35**	1.53*	3.52**	1.41	2.94**
38	RK 9 x Laha 101	0.48	-3.59**	0.54	-6.49**	0.51	-5.04**
39	RK 14 x Laha 101	-1.78	1.24	-2.07**	2.97**	-1.92	2.11**
40	KRV47 x Laha 101	-3.15**	4.13**	-2.88**	2.52**	-3.02**	3.33**
41	RK8601 x Vaibhav	1.03	-2.82**	1.13	-1.50*	1.08	-2.16**
42	RK8602 x Vaibhav	2.12*	-1.32	1.75*	-1.03	1.93	-1.17*
43	RK 8604 x Vaibhav	0.85	1.91*	-0.59	2.08**	0.13	1.99**
44	RK 8605 x Vaibhav	1.37	0.96	-0.23	0.39	0.57	0.68
45	RK 8608 x Vaibhav	-2.22**	-2.87**	0.82	-2.47**	-0.70	-2.67**
46	RK 8701 x Vaibhav	2.18*	-1.31	2.42**	-1.14	2.30*	-1.23*
47	RK 8702 x Vaibhav	-3.63**	0.74	-3.57**	0.84	-3.60**	0.79
48	RK 8801 x Vaibhav	1.45	0.57	1.15	0.30	1.30	0.44
49	RK 8802 x Vaibhav	-3.82**	0.80	-3.58**	-0.15	-3.70**	0.32
50	RK 8803 x Vaibhav	2.04*	-2.15**	2.10**	-3.16**	2.07*	-2.65**
51	RK 8901 x Vaibhav	1.78	1.35	1.48*	3.31**	1.63	2.33**
52	RK 8902 x Vaibhav	0.41	-0.42	0.42	-092	0.41	-0.67
53	RK 8903 x Vaibhav	0.25	-1.37	0.43	-0.60	0.34	-0.99
54	RK 9001 x Vaibhav	-0.66	1.79**	-0.85	1.52*	-0.75	-1.66**
55	RK 9002 x Vaibhav	-2.15*	2.02**	-1.92**	1.52*	-2.03	1.77**
56	RK 918506 x Vaibhav	-2.30*	-1.59*	-2.23**	-0.83	-2.27*	-1.21*
57	RK 911296 x Vaibhav	4.45**	-0.43	4.15**	-0.70	4.30**	-0.57
58	RK 9 x Vaibhav	3.74*	-0.42	3.30**	-0.92	3.52**	-0.67
59	RK 14 x Vaibhav	-2.74	0.96	-1.34	1.73**	-2.04	1.34**
60	KRV47 x Vaibhav	-1.00	-0.54	-1.96**	-0.81	-1.48	-0.67
	SE ($\hat{S}_{ij}$)	0.94	0.77	0.72	0.66	1.03	0.51

Table 7: Contd.

S. No.	Crosses	Days to reproductive phase					
		Normal Sown(E_1)		Late Sown(E_2)		Pooled	
		F_1	F_2	F_1	F_2	F_1	F_2
1	RK 8601x M. Rai	-2.67**	-1.68	-2.02**	-1.10**	-2.34**	-1.39
2	RK8602 x M. Rai	0.81	0.12	0.15	0.25	0.48	0.18
3	RK8604 x M. Rai	1.86	1.57	1.87**	0.86*	1.86**	1.21
4	RK8605 x M. Rai	3.67**	-2.13	2.09**	-1.10**	2.88**	-1.61*
5	RK8608 x M. Rai	2.14*	0.67	1.26*	0.25	1.70**	0.46
6	RK8701 x M. Rai	-5.81**	1.45	-3.35**	0.86*	-4.58**	1.16
7	RK8702 x M. Rai	-1.34	4.99	-1.13*	3.79**	-1.24*	4.39**
8	RK8801 x M. Rai	-0.18	-0.88	-0.29	-0.86*	-0.24	-0.87
9	RK8802 x M. Rai	1.52	-4.10	1.42**	-2.92**	1.47**	-3.51**
10	RK8803 x M. Rai	-0.44	-0.02	-0.57	-0.33	-0.51	-0.17
11	RK8901 x M. Rai	-1.97	-3.55**	-1.41**	-3.31**	-1.69**	-3.43**
12	RK8902 x M. Rai	2.41*	3.56**	1.98**	3.64**	2.20**	3.60**
13	RK8903 x M. Rai	-4.67**	-2.01	-3.57**	0.90*	-4.12**	-0.56
14	RK9001 x M. Rai	4.82**	1.78	3.60**	-1.08**	4.21**	0.35
15	RK9002 x M. Rai	-0.15	0.23	-0.03	0.19	-0.09	0.21
16	RK918506 x M. Rai	-0.84	5.43**	1.33**	-1.88**	0.24	1.77*
17	RK 911296 x M.Rai	-1.36	-4.43**	0.81	0.14	-0.28	-2.15**
18	RK 9 x M. Rai	2.21**	-0.99	-2.14**	1.75**	0.03	0.38
19	RK 14 x M. Rai	-0.22	-4.24**	-0.46	-2.55**	-0.34	-3.39**
20	KRV 47 x M. Rai	2.26*	-0.11	1.37**	-0.20	1.82**	-0.15
21	RK8601 x Laha 101	-2.04*	4.34**	-0.91	2.74**	-1.47**	3.54**
22	RK8602 x Laha 101	0.22	6.54**	-0.13	4.79**	0.05	5.66**
23	RK 8604 x Laha 101	-4.30**	-2.32	-3.29**	-1.86**	-3.80**	-2.09**
24	RK8605 x Laha 101	4.08**	-4.21**	3.42**	-2.92**	3.75**	-3.57**
25	RK8608 x Laha 101	1.11	2.21	0.21	1.67**	0.66	1.94**
26	RK8701 x Laha 101	1.92	-0.33	1.37**	-0.31	1.65**	-0.32
27	RK8702 x Laha 101	-3.03**	-1.88	-1.58**	-1.37**	-2.30**	-1.62*
28	RK8801x Laha 101	-1.33	1.33	3.43**	1.01*	1.05	1.16
29	RK8802 x Laha 101	2.14*	0.78	-4.07**	0.36	-0.96	0.57
30	RK8803 x Laha 101	-0.81	-2.10	0.64	-1.36**	-0.08	-1.73*
31	RK 8901 x Laha 101	1.45	0.87	-2.68**	0.78	-0.62	0.83
32	RK 8902 x Laha 101	-6.08**	3.67**	2.48**	2.47**	-1.80**	3.07**
33	RK 8903 x Laha 101	4.63**	-4.55**	0.02	-3.25**	2.42**	-3.90**
34	RK 9001 x Laha 101	1.44	-2.80*	0.66	-1.44**	1.05	-2.12**
35	RK 9002 x Laha 101	-5.41**	2.67	-3.88**	1.58**	-4.64**	2.13**
36	RK 918506x Laha 101	3.97**	0.12	3.22**	-0.14	3.59**	-0.01
37	RK911296 x Laha 101	3.89**	-2.68	2.55**	-1.44**	3.22**	-2.06**
38	RK 9 x Laha 101	-0.30	0.78	-0.63	0.24	-0.47	0.51
39	RK 14 x Laha 101	-3.59**	1.90	-1.92	1.19**	-2.75**	1.55*
40	KRV47 x Laha 101	-1.78	-0.67	-0.24	0.01	-1.01	-0.33
41	RK8601 x Vaibhav	0.37	2.44	1.27**	1.36**	0.82	1.90**
42	RK8602 x Vaibhav	1.41	-1.76	-1.02*	-1.36**	0.19	-1.56*
43	RK 8604 x Vaibhav	-0.89	-5.57**	-0.69	-3.44**	-0.79	-4.50**
44	RK 8605 x Vaibhav	1.93	-0.44	0.82	-0.42	1.37**	-0.43
45	RK 8608 x Vaibhav	-1.04	6.01**	-0.13	3.86**	-0.58	4.94**
46	RK 8701 x Vaibhav	6.11**	-0.48	4.43**	-1.66**	5.27**	-1.07
47	RK 8702 x Vaibhav	-0.07	-1.32	-1.07*	1.69**	-0.57	0.19
48	RK 8801 x Vaibhav	-6.04**	1.80	-3.36**	-0.03	-4.70**	0.88
49	RK 8802 x Vaibhav	-3.00**	1.09	-2.13**	1.12**	-2.57**	1.11
50	RK 8803 x Vaibhav	0.82	0.56	0.37**	0.14	0.59	0.35
51	RK 8901 x Vaibhav	2.18*	-1.66	1.76**	-1.25**	1.97**	1.45*
52	RK 8902 x Vaibhav	-0.78	-0.79	-0.79	-0.21	-0.79	-0.50
53	RK 8903 x Vaibhav	-0.63	-2.99*	-0.63	-1.86**	-0.63	-2.43**
54	RK 9001 x Vaibhav	1.41	3.79**	1.42**	2.07**	1.42**	2.93**
55	RK 9002 x Vaibhav	4.89**	2.76*	3.20**	2.23**	4.04**	2.50**
56	RK 918506 x Vaibhav	1.37	1.56	0.71	0.92**	1.04	1.24
57	RK 911296 x Vaibhav	-6.26**	-4.33**	-3.91**	-3.14**	-5.08**	-3.73**
58	RK 9 x Vaibhav	-4.78**	-2.13	-3.46**	-1.15**	4.12	-1.64
59	RK 14 x Vaibhav	1.71	1.34	1.04*	0.53	1.38*	0.94
60	KRV47 x Vaibhav	3.07**	0.78	2.42**	0.61	2.75**	0.70
	SE ($\hat{S}_{ij}$)	1.00	1.38	0.51	0.42	0.56	0.72

Table 7: Contd.

S. No.	Crosses	Number of primary branches					
		Normal Sown(E_1)		Late Sown(E_2)		Pooled	
		F_1	F_2	F_1	F_2	F_1	F_2
1	RK 8601x M. Rai	-2.71**	-1.68**	-1.82**	-1.36**	-2.26**	-1.52**
2	RK8602 x M. Rai	3.62**	-2.13**	2.29**	-1.36**	2.96**	-1.74**
3	RK8604 x M. Rai	-1.38*	4.98**	-0.93*	3.53**	-1.15**	4.26**
4	RK8605 x M. Rai	-0.49	0.02	-0.37	0.20	-0.43	0.09
5	RK8608 x M. Rai	-4.71**	-1.79**	-3.04*	-1.13**	-3.88**	-1.46**
6	RK8701 x M. Rai	-0.93	5.43**	-0.48	3.76**	-0.71*	4.59**
7	RK8702 x M. Rai	-0.27	-4.24**	-0.26	-2.80**	-0.26	-3.52**
8	RK8801 x M. Rai	0.18	6.54**	0.02	4.53**	0.12	5.54**
9	RK8802 x M. Rai	1.07	2.21**	0.63	1.42**	0.85**	1.81**
10	RK8803 x M. Rai	-1.38*	1.32**	-1.04**	0.76**	-1.21**	1.04**
11	RK8901 x M. Rai	1.40**	0.87	0.85*	0.53	1.12**	0.70*
12	RK8902 x M. Rai	1.40**	2.79*	0.85*	-1.69**	1.12**	-2.24**
13	RK8903 x M. Rai	3.84**	3.68**	2.74**	-1.69**	3.29**	-2.19**
14	RK9001 x M. Rai	-1.82**	-0.68	-1.15**	-0.24	-1.49**	-0.46
15	RK9002 x M. Rai	-0.93	-5.57**	-0.48	-3.69**	-0.71*	-4.63**
16	RK918506 x M. Rai	6.73**	-0.68	4.63**	-1.91**	5.69**	-1.30**
17	RK 911296 x M.Rai	-2.82**	1.09*	-1.93**	0.87**	-2.38**	0.98**
18	RK 9 x M. Rai	-0.82	-0.79	-0.59	-0.36	-0.71*	-0.58
19	RK 14 x M. Rai	4.84**	2.76**	3.29**	1.95**	4.07**	2.37**
20	KRV 47 x M. Rai	-4.82**	-2.13**	-3.26**	-1.36**	-4.04**	-1.74**
21	RK8601 x Laha 101	0.89	0.13	0.42	0.28	0.65	0.21
22	RK8602 x Laha 101	2.22**	0.69	1.53**	0.28	1.88**	0.48
23	RK 8604 x Laha 101	-0.11	-0.87	-0.03	-0.83**	-0.07	-0.85**
24	RK8605 x Laha 101	-1.89**	-3.53**	-1.14**	-2.50**	-1.51**	-3.02**
25	RK8608 x Laha 101	4.89**	1.69**	3.19**	1.17**	4.04**	1.43**
26	RK8701 x Laha 101	-1.33*	-4.42**	-0.92*	-3.28**	-1.12**	-3.85**
27	RK8702 x Laha 101	2.33**	0.09	1.04**	-1.17	1.99**	-0.13
28	RK8801x Laha 101	-4.22**	-2.31**	-3.03**	-1.83**	-3.62**	-3.07**
29	RK8802 x Laha 101	2.00**	-0.31	1.53**	-0.28	-1.76**	-0.29
30	RK8803 x Laha 101	2.22**	0.80	1.53**	0.39	1.88**	0.59
31	RK 8901 x Laha 101	-6.00**	3.69**	-3.92**	2.50**	-4.96**	3.09**
32	RK 8902 x Laha 101	-5.33**	2.69**	-3.58**	1.61**	-4.46**	2.15**
33	RK 8903 x Laha 101	-0.22	0.80	-0.36	0.28	-0.29	0.54
34	RK 9001 x Laha 101	0.44	2.47**	0.42	1.37**	0.43	1.93**
35	RK 9002 x Laha 101	2.00**	-0.42	1.08**	-0.39	1.54**	-0.41
36	RK 918506x Laha 101	-1.33*	1.53**	-0.81*	-1.77**	-1.07**	0.09
37	RK911296 x Laha 101	0.78	0.58	0.64	0.17	0.71*	0.37
38	RK 9 x Laha 101	-0.56	2.98**	-0.36	-2.06	-0.46	-2.52**
39	RK 14 x Laha 101	1.44**	1.58**	0.86	0.94**	1.15**	1.26**
40	KRV47 x Laha 101	1.78**	1.36**	1.31**	0.61*	1.54**	0.98**
41	RK8601 x Vaibhav	1.82**	1.55**	1.40**	1.08**	1.61**	1.31**
42	RK8602 x Vaibhav	-5.84**	1.44**	-3.82**	1.08**	-4.83**	1.26**
43	RK 8604 x Vaibhav	1.49**	-4.12**	0.96**	2.70**	1.22**	-3.41**
44	RK 8605 x Vaibhav	2.38**	3.55**	1.51**	2.30**	1.94**	2.93**
45	RK 8608 x Vaibhav	-0.18	0.11	-0.16	-0.03	-0.17	0.04
46	RK 8701 x Vaibhav	2.27**	-1.01	1.40**	-0.41	1.83**	-0.74*
47	RK 8702 x Vaibhav	-2.07**	4.33**	-1.38**	-2.97**	-1.72**	3.65**
48	RK 8801 x Vaibhav	4.04**	4.23**	2.96**	-2.70**	3.50**	-3.46**
49	RK 8802 x Vaibhav	-3.07**	-1.89**	-3.16**	1.14**	-2.61**	-1.52**
50	RK 8803 x Vaibhav	-0.84	-2.12**	-0.49	1.14**	-0.67	-1.63**
51	RK 8901 x Vaibhav	4.60**	4.56**	0.07	-3.03**	3.83**	-3.80**
52	RK 8902 x Vaibhav	3.93**	0.11	2.73**	0.08	3.33**	0.09
53	RK 8903 x Vaibhav	3.62**	1.88**	-2.38**	1.41**	-3.00**	1.65**
54	RK 9001 x Vaibhav	1.38*	-1.78**	0.73	-1.14**	1.06**	-1.46**
55	RK 9002 x Vaibhav	-1.07	5.99**	-0.60	-4.08**	-0.83*	5.04**
56	RK 918506 x Vaibhav	-5.40**	2.22**	-3.82**	0.19	-4.61**	1.20**
57	RK 911296 x Vaibhav	2.04**	-1.67**	1.29**	-1.03**	1.67**	-1.35**
58	RK 9 x Vaibhav	1.38*	3.77**	-2.41**	1.17**	3.09**	3.09**
59	RK 14 x Vaibhav	-6.29**	-4.34**	-4.16**	-2.92**	-5.22**	-3.63**
60	KRV47 x Vaibhav	3.04**	0.77	1.96**	-0.74*	2.50**	0.76**
	SE ($\hat{S}_{ij}$)	0.56	0.52	0.38	0.30	0.34	0.30

Table 7: Contd.

S. No.	Crosses	Number of secondary branches					
		Normal Sown(E_1)		Late Sown(E_2)		Pooled	
		F_1	F_2	F_1	F_2	F_1	F_2
1	RK 8601x M. Rai	-0.67	-0.96**	-0.45	-0.72*	-0.56	-0.84**
2	RK8602 x M. Rai	-1.56**	0.16	-0.8**	0.06	-1.32**	0.11
3	RK8604 x M. Rai	-2.89**	-1.62**	-2.01**	-0.64*	-2.45**	-1.13**
4	RK8605 x M. Rai	-0.34	-0.18	-0.22	-0.18	-0.28	-0.18
5	RK8608 x M. Rai	1.53**	-1.02	1.10**	-0.25	1.33**	-0.66**
6	RK8701 x M. Rai	-0.12	0.04	-0.07	-0.02	-0.09	0.01
7	RK8702 x M. Rai	-0.23	0.16	-0.14	0.06	-0.19	0.11
8	RK8801 x M. Rai	1.88**	0.27	1.37**	0.14	1.63**	0.20
9	RK8802 x M. Rai	3.55**	-0.07	2.50**	-0.10	3.03**	-0.08
10	RK8803 x M. Rai	2.77**	0.04	1.94**	-0.02	2.35**	0.01
11	RK8901 x M. Rai	-0.67	0.93	-0.12	0.60	-0.40	0.77**
12	RK8902 x M. Rai	0.33	-1.07**	0.25	-0.78*	0.29	-0.92**
13	RK8903 x M. Rai	-3.01**	0.60	-2.09**	0.29	-2.55**	0.45
14	RK9001 x M. Rai	0.44	0.27	-0.30	0.14	0.07	0.20
15	RK9002 x M. Rai	0.33	0.71	0.25	0.45	0.29	0.58*
16	RK918506 x M. Rai	-0.23	-0.40	-0.14	-0.33	-0.19	-0.37
17	RK 911296 x M.Rai	0.99	0.16	0.66	0.06	0.83**	0.11
18	RK 9 x M. Rai	0.88	1.27**	0.64	0.84**	0.76**	1.05**
19	RK 14 x M. Rai	-2.01	0.60	-1.39**	0.37	-1.70**	0.48
20	KRV 47 x M. Rai	-1.01	0.16	-0.69	0.06	-0.85**	0.11
21	RK8601 x Laha 101	-1.17*	1.29**	-0.80*	0.96**	-0.98**	1.13**
22	RK8602 x Laha 101	2.27**	0.07	1.62**	0.11	1.94**	0.09
23	RK 8604 x Laha 101	0.61	0.63	0.45	-0.59	0.53	0.02
24	RK8605 x Laha 101	1.16*	1.74**	0.84*	1.27**	1.00**	1.51**
25	RK8608 x Laha 101	1.38**	1.52**	0.99**	1.66**	1.19**	1.59**
26	RK8701 x Laha 101	-1.28*	-0.71	-0.87*	-0.44	-1.08**	-0.57*
27	RK8702 x Laha 101	-0.73	-0.93*	-0.48	-0.59	-0.61	-0.76**
28	RK8801x Laha 101	-1.28*	0.18	-0.94**	0.19	-1.11**	0.18
29	RK8802 x Laha 101	-3.62**	0.85*	-2.51**	0.65*	-3.06**	0.75**
30	RK8803 x Laha 101	-1.06	-0.71	-0.71	-0.44	-0.88**	-0.57*
31	RK 8901 x Laha 101	0.83	-1.15**	-0.06	-0.75*	0.38	-0.95**
32	RK 8902 x Laha 101	0.83	0.52	0.60	0.37	0.72*	0.45
33	RK 8903 x Laha 101	0.49	0.18	0.37	-0.36	0.43	-0.09
34	RK 9001 x Laha 101	1.27*	-0.15	1.23**	-0.04	1.25**	-0.10
35	RK 9002 x Laha 101	-1.17*	-0.37	-0.80*	-0.20	-0.98**	-0.29
36	RK 918506x Laha 101	0.94	0.18	0.68	0.09	0.81*	0.18
37	RK911296 x Laha 101	0.49	-1.59**	0.28	-1.06**	0.39	-1.33**
38	RK 9 x Laha 101	-1.28*	-0.82*	-0.87*	-0.91	-1.08**	-0.67**
39	RK 14 x Laha 101	1.49**	-0.48	1.07**	-0.28	1.28**	-0.32
40	KRV47 x Laha 101	-0.17	-0.26	-0.10	-0.13	-0.13	-0.19
41	RK8601 x Vaibhav	1.84**	-0.34	1.25**	-0.24	-1.55**	-0.29
42	RK8602 x Vaibhav	-0.71	-0.23	-0.54	-0.16	-0.63	-0.20
43	RK 8604 x Vaibhav	2.29**	0.99**	1.56**	1.24**	1.92**	1.12**
44	RK 8605 x Vaibhav	-0.82	-1.56**	-0.62	-1.10**	-0.72	-1.33**
45	RK 8608 x Vaibhav	-2.93**	-0.45	-2.10**	-1.41**	-2.57**	-0.93**
46	RK 8701 x Vaibhav	1.40**	0.66	0.91*	0.46	-1.17**	0.56*
47	RK 8702 x Vaibhav	0.96	0.77*	0.63	0.54	0.79*	0.65**
48	RK 8801 x Vaibhav	-0.60	-0.45	-0.43	-0.32	-0.51	-0.38
49	RK 8802 x Vaibhav	0.07	-0.78*	0.00	-0.55	0.04	-0.67**
50	RK 8803 x Vaibhav	-1.71**	0.66	-1.23**	0.46	-1.47**	0.56*
51	RK 8901 x Vaibhav	-0.16	0.22	0.18	0.15	0.01	0.18
52	RK 8902 x Vaibhav	-1.16*	0.55	-0.05*	0.40	-1.00**	0.48
53	RK 8903 x Vaibhav	2.51**	-0.78*	1.72**	0.07	2.11**	-0.36
54	RK 9001 x Vaibhav	-1.71**	-0.12	-0.93**	-0.09	-1.32**	-0.10
55	RK 9002 x Vaibhav	0.84	-0.34	0.55	-0.24	-0.70*	-0.29
56	RK 918506 x Vaibhav	-0.71	0.22	-0.54	0.15	-0.63	0.18
57	RK 911296 x Vaibhav	-1.49**	1.44**	-0.94**	1.00**	-1.21**	1.22**
58	RK 9 x Vaibhav	0.40	-0.45	0.24	-0.32	0.32	-0.38
59	RK 14 x Vaibhav	0.51	-0.12	-0.32	-0.09	0.41	-0.10
60	KRV47 x Vaibhav	1.18*	0.11	0.78*	0.07	0.98**	0.09
	SE ($\hat{S}_{ij}$)	0.54	0.38	0.37	0.32	0.33	0.25

Table 7: Contd.

S. No.	Crosses	Height of plant					
		Normal Sown(E_1)		Late Sown(E_2)		Pooled	
		F_1	F_2	F_1	F_2	F_1	F_2
1	RK 8601x M. Rai	1.61	-4.00	2.53**	-12.18**	2.07	-8.09**
2	RK8602 x M. Rai	-5.55*	1.20	-3.11**	16.87**	-4.33**	9.03**
3	RK8604 x M. Rai	3.95	2.79	0.59	-4.69**	2.27	-0.95
4	RK8605 x M. Rai	2.93	-0.22	3.30	-10.96**	3.12**	-5.59**
5	RK8608 x M. Rai	-7.22**	1.98	-4.00**	3.42**	-5.61**	2.70*
6	RK8701 x M. Rai	4.28	-1.77	0.70	7.54**	2.49*	2.89**
7	RK8702 x M. Rai	-4.84*	-1.77	-7.24**	-9.96**	-6.04**	-5.87**
8	RK8801 x M. Rai	-4.99*	2.43	0.12	2.42**	-2.44*	2.42*
9	RK8802 x M. Rai	9.83**	-0.65	7.13**	7.54**	8.48**	3.44**
10	RK8803 x M. Rai	-2.95	0.11	-5.92**	4.38**	-4.43**	2.24*
11	RK8901 x M. Rai	7.56**	-1.35	16.44**	-1.25	12.00**	-1.30
12	RK8902 x M. Rai	-4.60	1.24	-10.53**	-3.13**	-7.57**	-0.94
13	RK8903 x M. Rai	0.16	3.89	-6.62**	10.27**	-3.23**	7.08**
14	RK9001 x M. Rai	-3.00	1.42	3.08**	-10.03**	0.04	-4.30**
15	RK9002 x M. Rai	2.84	-5.32**	3.55**	-0.24	3.19**	-2.78**
16	RK918506 x M. Rai	2.16	3.45	-4.59**	2.27**	-1.21	2.86**
17	RK 911296 x M.Rai	-2.33	-9.68**	-0.55	12.97**	-1.44	1.64
18	RK 9 x M. Rai	0.17	6.24**	5.14**	-15.24**	-2.65*	-4.50**
19	RK 14 x M. Rai	5.60*	12.22**	7.75**	5.93**	6.68**	9.08**
20	KRV 47 x M. Rai	6.11**	-16.24**	8.78**	5.98**	7.45**	-5.13**
21	RK8601 x Laha 101	-11.72**	4.01	16.53**	-11.91**	-14.12**	-3.95**
22	RK8602 x Laha 101	0.16	-7.78**	6.41**	3.38**	3.29**	-2.20*
23	RK 8604 x Laha 101	-4.99*	8.43**	-12.22**	-.6.25**	-8.61**	1.09
24	RK8605 x Laha 101	4.84*	-.-0.65	5.81**	2.87**	5.32**	1.11
25	RK8608 x Laha 101	5.60*	5.56**	27.75**	9.20**	16.67**	7.38**
26	RK8701 x Laha 101	-1.22	1.10	-7.22**	-4.99**	-4.22**	-1.95
27	RK8702 x Laha 101	-4.38	-6.65**	-20.52**	-4.21**	-12.45**	-5.43**
28	RK8801x Laha 101	-0.95	4.78*	10.30**	5.26**	4.67**	5.02**
29	RK8802 x Laha 101	-3.77	-7.35**	-6.33	7.31**	-5.05**	-0.02
30	RK8803 x Laha 101	4.73*	2.57	3.97**	-12.57**	0.38	5.10**
31	RK 8901 x Laha 101	6.94**	-9.22**	4.08**	2.93**	5.51**	-3.14**
32	RK 8902 x Laha 101	-10.22**	7.65**	-8.89**	-17.35**	-9.55**	-4.85**
33	RK 8903 x Laha 101	3.28	1.57	4.81**	14.42**	4.04**	8.10**
34	RK 9001 x Laha 101	-6.29**	2.01	-3.26**	-5.62**	-4.77**	-1.81
35	RK 9002 x Laha 101	32.89**	8.54	25.44**	17.42**	29.17**	12.98**
36	RK 918506x Laha 101	-26.61**	-10.54**	-22.19**	-11.80**	-24.40**	-11.17**
37	RK911296 x Laha 101	-3.06	-1.55	-5.92	2.04**	-4.49**	0.25
38	RK 9 x Laha 101	12.78**	0.98	20.45**	-0.58	16.61**	0.20
39	RK 14 x Laha 101	-9.72**	0.57-	14.52**	-1.46*	-12.12**	-0.45
40	KRV47 x Laha 101	9.71**	7.78**	23.08**	18.82**	16.39**	13.30**
41	RK8601 x Vaibhav	5.56*	-17.68**	-1.88**	-19.47**	1.84	-18.58**
42	RK8602 x Vaibhav	-15.27**	9.98**	-21.19**	0.65	-18.23**	5.27**
43	RK 8604 x Vaibhav	-13.28**	-2.55	-23.59**	6.15**	-18.44**	1.80
44	RK 8605 x Vaibhav	2.89	2.98	0.78	13.20**	1.84	8.09**
45	RK 8608 x Vaibhav	10.39**	-0.43	22.81**	-19.35**	16.60**	-9.89**
46	RK 8701 x Vaibhav	-0.84	10.89**	-15.37**	14.15**	-8.10**	12.52**
47	RK 8702 x Vaibhav	1.34	-7.24**	-10.66**	-0.80	-4.66**	-4.02**
48	RK 8801 x Vaibhav	0.49	-3.65	26.03**	-13.35**	12.77**	-8.50**
49	RK 8802 x Vaibhav	3.38	-3.44	19.19**	-14.18**	11.28**	-8.81**
50	RK 8803 x Vaibhav	-16.77**	9.43**	-32.78**	-1.80**	-24.78**	3.81**
51	RK 8901 x Vaibhav	13.40**	-5.98**	13.59**	15.98**	13.49**	5.00**
52	RK 8902 x Vaibhav	0.60	-3.33	-8.92**	-1.84**	-4.16**	-2.59**
53	RK 8903 x Vaibhav	-5.89**	3.54	13.89**	-1.14	-9.89**	1.20
54	RK 9001 x Vaibhav	5.29*	-0.21	22.81**	2.98**	14.05**	1.39
55	RK 9002 x Vaibhav	1.05	-17.77**	1.52**	-22.62**	1.29	-20.20**
56	RK 918506 x Vaibhav	-3.77	9.43**	7.22**	0.75	1.73	5.09**
57	RK 911296 x Vaibhav	2.73	8.35**	-8.75**	21.87**	-3.01**	15.11**
58	RK 9 x Vaibhav	-7.69**	0.92	-24.48**	-7.46**	-16.08**	-3.24**
59	RK 14 x Vaibhav	0.60	0.46	19.22**	-16.69**	9.91**	-8.12**
60	KRV47 x Vaibhav	7.10**	-1.38	5.25**	24.09**	6.17**	11.36**
	SE ($\hat{S}_{ij}$)	2.31	2.09	0.59	0.68	1.19	1.10

Table 7: Contd.

S. No.	Crosses	Length of main fruiting branch					
		Normal Sown(E_1)		Late Sown(E_2)		Pooled	
		F_1	F_2	F_1	F_2	F_1	F_2
1	RK 8601x M. Rai	4.66**	15.84**	2.22	5.46**	3.44**	10.65**
2	RK8602 x M. Rai	3.86*	-6.96**	1.17	-5.08**	2.52*	-6.02**
3	RK8604 x M. Rai	-8.52**	-8.89**	-3.40*	-0.38	-5.96**	-4.63**
4	RK8605 x M. Rai	1.99	1.40	0.45	-6.87**	1.22	-2.74**
5	RK8608 x M. Rai	-9.81**	-0.07	-3.94*	14.25**	-6.87**	7.09**
6	RK8701 x M. Rai	7.81**	-1.33	3.49*	-7.38**	5.65**	-4.35**
7	RK8702 x M. Rai	2.88	-0.62	1.67	0.02	2.28	-030
8	RK8801 x M. Rai	-1.58	1.95*	-1.39	1.47	-1.49	1.71**
9	RK8802 x M. Rai	-1.30	-1.32	-0.29	-1.50	-0.79	-1.41*
10	RK8803 x M. Rai	-8.67**	-0.05	-3.66*	0.24	-6.17**	0.10
11	RK8901 x M. Rai	11.19**	1.15	4.62**	1.03	7.90**	1.09
12	RK8902 x M. Rai	-2.52	-1.11	-0.95	-1.27	-1.74	-1.19*
13	RK8903 x M. Rai	4.33*	-3.60**	2.34	1.46	3.33**	-1.07
14	RK9001 x M. Rai	-4.80**	5.93**	-2.72	-2.75**	-3.76**	1.59*
15	RK9002 x M. Rai	0.47	-2.33**	0.38	1.28	0.43	-0.52
16	RK918506 x M. Rai	-8.00**	-5.99**	-4.64**	-2.09**	-6.32**	--3.79**
17	RK 911296 x M.Rai	3.19	-0.96	3.44*	0.03	3.32**	-0.46
18	RK 9 x M. Rai	4.81**	6.44**	1.20	2.06**	3.01**	4.25**
19	RK 14 x M. Rai	-0.01	-12.94**	-0.55	-8.32**	-0.28	-10.63**
20	KRV 47 x M. Rai	3.86*	11.93**	2.73	2.81**	3.29**	7.37**
21	RK8601 x Laha 101	-3.85*	1.00	-2.17	5.51**	-3.01**	3.26**
22	RK8602 x Laha 101	3.99*	7.18**	2.78	3.68**	3.39**	5.43**
23	RK 8604 x Laha 101	-9.47**	-1.96*	-6.60**	-0.52	-8.04**	-1.24*
24	RK8605 x Laha 101	5.48**	-5.22**	3.83*	-3.16**	4.65**	-4.19**
25	RK8608 x Laha 101	7.99**	8.18**	6.00**	2.57**	7.00**	5.38**
26	RK8701 x Laha 101	1.53	-1.29	-0.72	-1.64*	0.40	-1.46**
27	RK8702 x Laha 101	-9.52**	-6.89**	-5.28**	-0.94	-7.40**	-3.91**
28	RK8801x Laha 101	-7.68**	7.29**	-3.64*	3.46**	-5.66**	5.38**
29	RK8802 x Laha 101	4.53**	-8.51**	2.27	-7.75**	3.40**	-8.13**
30	RK8803 x Laha 101	3.15	1.22	1.37	4.28**	2.26	2.75**
31	RK 8901 x Laha 101	-2.78	2.63**	-2.00	4.02**	-2.33	3.32**
32	RK 8902 x Laha 101	2.41	4.49**	1.61`	-.253**	11.24**	0.98
33	RK 8903 x Laha 101	0.37	-.711**	0.38	-1.50	-8.90**	-4.30**
34	RK 9001 x Laha 101	-4.01*	6.07**	-0.66	3.02**	-2.33	4.54**
35	RK 9002 x Laha 101	17.20**	-4.73**	5.28**	-1.53	11.24**	-3.13**`
36	RK 918506x Laha 101	13.19**	1.33	-4.62**	1.50	-8.90**	1.41*
37	RK911296 x Laha 101	-4.68**	-3.71**	-1.88	-0.21	-3.28**	1.96**
38	RK 9 x Laha 101	-3.80*	10.49**	-2.27	4.59**	-3.04**	7.54**
39	RK 14 x Laha 101	8.48**	-6.77**	4.16**	4.38**	6.32**	-5.58**
40	KRV47 x Laha 101	9.10**	6.18**	4.11**	3.01**	6.61**	4.60**
41	RK8601 x Vaibhav	0.97	-4.63**	0.06	-1.52	0.52	-3.07**
42	RK8602 x Vaibhav	-10.07**	-1.56	-4.18**	-1.49	-7.12**	-1.52**
43	RK 8604 x Vaibhav	0.44	-23.38**	0.45	-9.88**	0.45	-16.63**
44	RK 8605 x Vaibhav	-4.36**	18.49**	-2.61	8.59**	-3.49**	13.54**
45	RK 8608 x Vaibhav	3.92*	4.89**	2.16	1.29	3.04**	3.09**
46	RK 8701 x Vaibhav	-0.01	3.19**	-3.66*	-1.10	-1.83	1.05
47	RK 8702 x Vaibhav	5.53**	-3.28**	9.95**	0.37	7.74**	-1.46**
48	RK 8801 x Vaibhav	-5.52**	0.10	-6.29*	0.73	-5.91**	0.41
49	RK 8802 x Vaibhav	-7.12**	-2.39**	-2.11	-0.21	-4.61**	-1.30*
50	RK 8803 x Vaibhav	6.09**	-10.50**	2.84	-4.58**	4.46**	7.54**
51	RK 8901 x Vaibhav	1.03	12.90**	-0.73	4.78**	0.15	8.84**
52	RK 8902 x Vaibhav	6.44**	-11.71**	2.89	-4.77**	4.67**	8.24**
53	RK 8903 x Vaibhav	-5.36**	-0.18	-2.83	0.37	-4.10**	-0.09
54	RK 9001 x Vaibhav	-1.08	11.89**	-0.07	4.40**	-0.57	8.14**
55	RK 9002 x Vaibhav	1.88	-1.15	0.34	2.79**	1.11	0.82
56	RK 918506 x Vaibhav	-20.91**	-0.62	-10.38**	-1.08	-15.65**	-0.85
57	RK 911296 x Vaibhav	19.03**	1.78*	10.05**	-1.72*	14.54**	0.03
58	RK 9 x Vaibhav	-0.78	7.07**	-0.44	3.70**	0.61	5.39**
59	RK 14 x Vaibhav	-0.25	-10.74**	-0.49	-4.57**	-0.37	-7.65**
60	KRV47 x Vaibhav	1.03	3.67**	0.94	0.86	0.98	2.27**
	SE ($\hat{S}_{ij}$)	1.74	0.80	1.61	0.81	1.19	0.57

Table 7 : Contd.

S. No.	Crosses	Number of siliquae on main fruiting branch					
		Normal Sown(E_1)		Late Sown(E_2)		Pooled	
		F_1	F_2	F_1	F_2	F_1	F_2
1	RK 8601x M. Rai	4.99**	16.70**	2.21**	7.24**	3.60**	11.97**
2	RK8602 x M. Rai	1.21	2.26	0.43	0.68	0.82	1.47
3	RK8604 x M. Rai	3.21	0.03	1.65**	0.43	2.43**	-0.20
4	RK8605 x M. Rai	-8.34**	0.59	-3.68**	-0.21	-6.01**	0.19
5	RK8608 x M. Rai	5.10**	3.92	2.32**	1.02*	3.71**	2.47
6	RK8701 x M. Rai	-10.34**	-4.63	-4.79**	-2.54**	-7.57**	-3.59*
7	RK8702 x M. Rai	-1.34	-18.74**	-0.57	-8.76**	-0.96	-13.75**
8	RK8801 x M. Rai	6.32**	8.03*	2.76**	3.24**	4.54**	5.64**
9	RK8802 x M. Rai	13.66**	5.70	6.09**	2.13**	9.87**	3.91*
10	RK8803 x M. Rai	-8.34**	11.48**	-3.68**	3.24**	-6.01**	7.36**
11	RK8901 x M. Rai	3.64	-13.19	-1.57**	3.57**	-2.51**	-4.81**
12	RK8902 x M. Rai	-1.68	6.92*	-0.68	2.57**	-1.18	4.75**
13	RK8903 x M. Rai	-4.57**	-2.86	-1.91**	-1.76**	-3.24**	-2.31
14	RK9001 x M. Rai	9.43**	7.03*	4.09**	2.57**	6.76**	4.80**
15	RK9002 x M. Rai	0.77	-22.52**	0.43	-10.32**	0.60	-16.42**
16	RK918506 x M. Rai	-8.68**	-2.63	-3.68**	-1.54**	-6.18.**	2.09
17	RK 911296 x M.Rai	-5.12**	-1.52	-2.13**	-0.98	-3.63**	-1.25
18	RK 9 x M. Rai	6.77**	-10.86**	2.87**	-5.21**	4.82**	-8.03**
19	RK 14 x M. Rai	0.88	6.37	0.32	2.35**	0.60	4.36**
20	KRV 47 x M. Rai	-0.46	7.92*	-0.46	3.13**	-0.46	5.52**
21	RK8601 x Laha 101	2.76*	-7.13*	1.19*	-2.31**	1.97**	-4.72**
22	RK8602 x Laha 101	-8.69**	-0.24	-3.92**	0.81	-6.31**	0.28
23	RK 8604 x Laha 101	-2.69	1.87	-1.37*	2.02**	-2.03**	1.94
24	RK8605 x Laha 101	10.09**	1.09	4.63**	1.58**	7.73**	1.33
25	RK8608 x Laha 101	-6.13**	-7.58*	-2.70**	-2.20**	-4.42**	-4.89**
26	RK8701 x Laha 101	7.42**	-1.13	3.52**	0.58	5.47**	-0.28
27	RK8702 x Laha 101	6.09**	5.09	2.74**	3.36**	4.42**	4.22**
28	RK8801x Laha 101	-14.58**	-2.13	-6.59**	0.02	-10.58**	-1.06
29	RK8802 x Laha 101	-2.24	-4.81	-0.92	-1.09*	-1.58*	-2.94
30	RK8803 x Laha 101	5.42	-15.36**	2.30**	-7.31**	3.86**	-11.33**
31	RK 8901 x Laha 101	3.31*	37.64**	1.41**	1.98**	2.36**	17.83**
32	RK 8902 x Laha 101	12.09**	-4.91	5.30**	-0.95	8.69**	-2.94
33	RK 8903 x Laha 101	-5.13**	10.31**	-2.26**	5.69**	-3.69**	8.00**
34	RK 9001 x Laha 101	-0.13	-4.80	0.08	-0.98*	-0.03	-2.89
35	RK 9002 x Laha 101	-5.47**	18.31**	-2.59**	9.13**	-4.03**	13.72**
36	RK 918506x Laha 101	22.42**	-0.13	9.97**	0.91*	16.19**	0.39
37	RK911296 x Laha 101	6.64**	-10.69**	2.86**	-3.87**	4.75**	-7.28**
38	RK 9 x Laha 101	-6.47**	-0.36	-2.81**	0.91*	-4.64**	0.28
39	RK 14 x Laha 101	-23.36**	-4.13	-10.37**	-0.53	-16.86**	-2.33
40	KRV47 x Laha 101	-1.36	-10.31**	-0.48	-3.76**	-0.92	-7.33**
41	RK8601 x Vaibhav	-7.74**	-9.57**	-3.39**	-4.93	5.57**	-7.25**
42	RK8602 x Vaibhav	7.48**	-2.01	3.49**	-1.48**	5.49**	-1.75
43	RK 8604 x Vaibhav	-0.52	-1.90	-0.28	-1.59**	-0.40	-1.75
44	RK 8605 x Vaibhav	-1.74	-1.68	-0.95	-1.57**	-1.35*	-1.53
45	RK 8608 x Vaibhav	1.03	3.61	0.38	1.18**	0.71	2.42
46	RK 8701 x Vaibhav	2.92*	5.77	1.27*	1.96**	2.10**	3.86*
47	RK 8702 x Vaibhav	-4.74**	13.66*	-2.17**	5.41**	-3.46**	9.53**
48	RK 8801 x Vaibhav	8.26**	-5.90	3.83**	-3.26**	-6.04**	-7.58**
49	RK 8802 x Vaibhav	-11.41**	-0.90	-5.17**	-1.04	-8.29**	-0.97
50	RK 8803 x Vaibhav	2.92**	3.88	1.38*	4.07**	2.15**	3.97*
51	RK 8901 x Vaibhav	0.14	-24.46**	0.16	-1.59**	0.15	-13.03**
52	RK 8902 x Vaibhav	-10.41**	-2.01	-4.62**	-1.59**	-7.51**	-1.80
53	RK 8903 x Vaibhav	9.70**	-7.46*	4.16**	-3.93	6.93**	-5.67**
54	RK 9001 x Vaibhav	-9.30**	-2.23	-4.17**	-1.59**	-6.74**	-1.91
55	RK 9002 x Vaibhav	4.70**	4.21	2.16**	1.18**	3.43**	2.70
56	RK 918506 x Vaibhav	-13.74**	2.77	-6.28**	0.63	-10.11**	1.70
57	RK 911296 x Vaibhav	-1.52	12.21**	-0.73	4.85**	-1.12	8.53**
58	RK 9 x Vaibhav	-0.30	11.21**	-0.06	4.29**	-0.78	7.75**
59	RK 14 x Vaibhav	22.48**	-2.23	10.05**	-1.82**	16.26**	-2.03
60	KRV47 x Vaibhav	1.81	2.99	0.94	0.63	1.38*	1.81
	SE ($\hat{S}_{ij}$)	1.21	3.34	0.56	0.44	0.62	1.68

Table 7: Contd.

S. No.	Crosses	Days to maturity					
		Normal Sown(E_1)		Late Sown(E_2)		Pooled	
		F_1	F_2	F_1	F_2	F_1	F_2
1	RK 8601x M. Rai	1.99*	-2.41**	0.65	-2.18**	1.32*	-2.29**
2	RK8602 x M. Rai	-2.48**	2.73**	-0.28	2.16**	-1.38	2.44**
3	RK8604 x M. Rai	0.49	-0.32	0.37	0.02	0.06	-0.15
4	RK8605 x M. Rai	2.64**	-3.19**	-435**	-2.40**	-0.85	-2.79**
5	RK8608 x M. Rai	1.88*	0.95*	4.38**	0.60	3.13**	0.78
6	RK8701 x M. Rai	-4.52**	2.23**	-0.03	1.80*	-2.28**	2.02**
7	RK8702 x M. Rai	-2.14*	0.04	1.42	0.93	-0.36	0.49
8	RK8801 x M. Rai	-0.24	1.18**	2.83**	0.94	1.30*	1.06*
9	RK8802 x M. Rai	2.38**	-1.21**	-4.25**	-1.87*	0.94	-1.54**
10	RK8803 x M. Rai	0.43	-0.07	0.32	-1.07	0.37	-0.57
11	RK8901 x M. Rai	-3.35**	-2.96**	-2.62**	-2.40**	-2.98**	-2.68**
12	RK8902 x M. Rai	2.92**	3.02**	2.30**	3.47**	2.61**	3.25**
13	RK8903 x M. Rai	-5.91**	-3.40**	-4.01**	-0.62	-4.96**	-2.01**
14	RK9001 x M. Rai	8.99*	2.40**	5.72**	-0.62	7.36**	0.89*
15	RK9002 x M. Rai	-3.08**	1.01**	-1.71	1.24	-2.39**	1.12**
16	RK918506 x M. Rai	-0.68	4.26**	1.98*	-4.51**	0.65	-0.13
17	RK 911296 x M.Rai	-3.12**	-7.93**	-0.94	0.16	-2.03**	-3.89**
18	RK 9 x M. Rai	3.81**	3.68**	-1.04	4.35**	1.39*	4.01**
19	RK 14 x M. Rai	-0.47	-4.52**	-0.36	-3.18**	-0.41	-3.85**
20	KRV 47 x M. Rai	2.44**	2.61**	1.06	1.82*	1.75**	2.22**
21	RK8601 x Laha 101	-1.97*	1.90**	-0.70	1.36	-1.33*	1.63**
22	RK8602 x Laha 101	-0.91	6.04**	-1.24	2.82**	-1.08	4.43**
23	RK 8604 x Laha 101	2.32*	-1.48**	-0.84	-1.84*	0.74	-1.66**
24	RK8605 x Laha 101	-1.41	-4.57**	2.08*	-0.98	0.33	-2.77**
25	RK8608 x Laha 101	-1.69	2.38**	-1.46	-2.62**	-1.57*	-0.12
26	RK8701 x Laha 101	3.88**	-1.18**	2.60**	3.71**	3.24**	1.26**
27	RK8702 x Laha 101	-2.19*	-1.20**	-1.14	-1.09	-1.67**	-1.15
28	RK8801x Laha 101	-0.03	2.05**	4.87**	0.15	2.42**	1.10*
29	RK8802 x Laha 101	1.88*	0.81*	-4.72**	1.16	-1.42*	0.99
30	RK8803 x Laha 101	-1.85	-2.86**	-0.15	-1.31	-1.00	-2.09**
31	RK 8901 x Laha 101	2.31*	1.92**	-2.02*	1.04	0.15	1.48**
32	RK 8902 x Laha 101	-6.78**	5.40**	2.05*	3.71**	-2.37**	4.56**
33	RK 8903 x Laha 101	4.47**	-7.32**	-0.03	-4.75**	2.22**	-6.04**
34	RK 9001 x Laha 101	5.19**	-3.30**	2.10*	-2.85**	3.65**	-3.07**
35	RK 9002 x Laha 101	-7.23**	4.17**	-4.86**	3.15**	-6.05**	3.66**
36	RK 918506x Laha 101	2.04*	-0.88*	2.76**	-0.30	2.40**	-0.59
37	RK911296 x Laha 101	5.31**	2.03**	3.87**	17.49**	4.59**	9.76**
38	RK 9 x Laha 101	0.22	-6.83**	-0.72	-14.18**	-0.25	-10.50**
39	RK 14 x Laha 101	-5.53**	4.79**	-3.15**	-3.31**	-4.34**	0.74
40	KRV47 x Laha 101	-4.80**	2.48**	-3.47**	2.16**	-4.13**	2.32*
41	RK8601 x Vaibhav	1.44	-0.72	0.61	-0.18	1.02	-0.45
42	RK8602 x Vaibhav	3.36**	-1.77**	2.86**	-1.98**	3.11**	-1.87**
43	RK 8604 x Vaibhav	-1.58	-1.41**	-0.69	-1.73*	-1.13	-1.57**
44	RK 8605 x Vaibhav	1.66	-0.61	0.39	-0.07	1.02	-0.34
45	RK 8608 x Vaibhav	-0.08	2.01**	0.30	1.80*	0.11	1.91**
46	RK 8701 x Vaibhav	11.31**	-2.85**	6.43**	-3.18**	-8.87**	-3.01**
47	RK 8702 x Vaibhav	-6.12**	1.95**	-4.17**	2.49**	-5.15**	2.22**
48	RK 8801 x Vaibhav	-5.19**	0.90*	-2.26*	0.69	-3.73**	0.79
49	RK 8802 x Vaibhav	-6.47**	1.81**	-4.68**	1.48*	-5.57**	1.65**
50	RK 8803 x Vaibhav	2.78**	-2.71**	1.71	-2.17**	2.24**	-2.44**
51	RK 8901 x Vaibhav	3.69**	0.90*	2.97**	0.69	3.33**	0.79
52	RK 8902 x Vaibhav	-0.47	-3.41**	-0.24	1.51	-0.35	-2.46**
53	RK 8903 x Vaibhav	-0.23	1.73**	-0.83	1.16	-0.53	1.46**
54	RK 9001 x Vaibhav	0.70	1.67**	1.07	0.35	0.88	1.01*
55	RK 9002 x Vaibhav	-2.44**	3.38**	1.87*	1.93*	-0.28	2.66**
56	RK 918506 x Vaibhav	1.71	-0.48	-1.06	-1.06	0.32	-0.77
57	RK 911296 x Vaibhav	0.73	-2.90**	-0.81	-0.87	-0.04	-1.88**
58	RK 9 x Vaibhav	-1.58	-1.85**	-1.02	-2.18**	-1.30*	-2.02**
59	RK 14 x Vaibhav	0.33	0.95*	-0.28	1.48	0.03	1.21**
60	KRV47 x Vaibhav	1.25	0.91*	1.30	0.70	1.27	0.80
	SE ($\hat{S}_{ij}$)	0.94	0.39	0.91	0.78	0.65	0.44

Table 7: Contd.

S. No.	Crosses	Relative water content					
		Normal Sown(E_1)		Late Sown(E_2)		Pooled	
		F_1	F_2	F_1	F_2	F_1	F_2
1	RK 8601x M. Rai	11.11**	2.93**	6.11**	1.67**	8.61**	2.30**
2	RK8602 x M. Rai	-16.33**	12.38**	-9.12**	7.12**	-12.73**	9.75**
3	RK8604 x M. Rai	-18.44**	-1.84*	-10.67**	-1.11*	-14.56**	-1.47**
4	RK8605 x M. Rai	8.56**	-0.18	4.66**	-0.22	6.61**	-0.20
5	RK8608 x M. Rai	-12.78**	-5.07**	-2.78*	-2.88**	-7.78**	-3.97**
6	RK8701 x M. Rai	-8.11**	3.38**	-3.12*	1.89**	-4.11**	2.64**
7	RK8702 x M. Rai	-2.00	-13.96**	-1.23	-8.11**	-1.61	-11.03**
8	RK8801 x M. Rai	-7.33**	6.60**	-4.34**	3.89**	-5.84**	5.25**
9	RK8802 x M. Rai	-2.33*	-5.62**	-1.45	-3.22**	-1.89*	-4.42**
10	RK8803 x M. Rai	-16.00**	3.49**	-9.45**	2.01**	-12.73**	2.73**
11	RK8901 x M. Rai	12.44**	1.16	6.99**	0.56	9.72**	0.86
12	RK8902 x M. Rai	6.78**	-2.40**	3.53**	-1.44**	5.16**	-1.92**
13	RK8903 x M. Rai	-18.89**	1.71	-11.01**	1.12**	-14.95**	1.41**
14	RK9001 x M. Rai	34.56**	0.82	18.55**	0.45	26.55**	0.64
15	RK9002 x M. Rai	20.44**	-0.29	11.33**	0.45	15.89**	0.08
16	RK918506 x M. Rai	1.44	-1.29	0.66	-1.11*	1.05	-1.20*
17	RK 911296 x M.Rai	2.56*	0.60	1.33	0.56	1.94*	0.58
18	RK 9 x M. Rai	-2.89**	-1.84*	-2.01	-1.11*	-2.45**	-1.47**
19	RK 14 x M. Rai	5.22**	-0.07	2.66*	-0.22	3.94**	-0.14
20	KRV 47 x M. Rai	-1.00	-0.57	-0.67	-0.33	-0.84	-0.42
21	RK8601 x Laha 101	12.43**	-4.55**	7.74**	-2.71**	10.08**	-3.63**
22	RK8602 x Laha 101	36.98**	-0.77	20.85**	-0.60	28.92**	-0.69
23	RK 8604 x Laha 101	25.54**	3.67**	14.96**	2.18**	20.25**	2.93**
24	RK8605 x Laha 101	-7.13**	-4.33**	-3.71**	-2.27**	-5.42**	-3.30**
25	RK8608 x Laha 101	10.54**	-4.55**	-2.82*	-2.60**	3.86**	-3.57**
26	RK8701 x Laha 101	-2.13	-23.44**	-0.82	-13.16**	-1.47	-18.30**
27	RK8702 x Laha 101	-3.35**	19.56**	-1.59	11.18**	-2.47**	15.37**
28	RK8801x Laha 101	-13.35**	-8.88**	-7.04**	-5.16**	-10.19**	-7.02**
29	RK8802 x Laha 101	3.65**	14.23**	2.52	8.07**	3.08**	11.15**
30	RK8803 x Laha 101	14.32**	4.01**	8.85**	2.29**	11.58**	3.15**
31	RK 8901 x Laha 101	-12.24**	-6.66**	-6.37**	-3.82**	-9.31**	-5.24**
32	RK 8902 x Laha 101	-5.57**	-1.55	-2.82*	-0.82	-4.19**	-1.19*
33	RK 8903 x Laha 101	-1.57	5.89**	-0.37	3.40**	-0.97	4.65**
34	RK 9001 x Laha 101	-11.79**	1.34	-5.85**	0.73	-8.81**	1.04
35	RK 9002 x Laha 101	-28.57**	2.23*	-15.71**	1.07	-22.14**	1.65**
36	RK 918506x Laha 101	1.43	1.36	1.29	0.51	1.36	0.54
37	RK911296 x Laha 101	-0.46	0.78	-0.04	0.18	-0.25	0.48
38	RK 9 x Laha 101	0.09	1.34	0.63	0.84	0.36	1.09*
39	RK 14 x Laha 101	-10.79**	1.12	-5.71**	0.73	-8.25**	0.93
40	KRV47 x Laha 101	-8.02**	0.01	-4.04**	-0.04	-6.03**	-0.02
41	RK8601 x Vaibhav	-23.54**	1.62	-13.84**	1.04	-18.69**	1.33**
42	RK8602 x Vaibhav	-20.65**	-11.61**	-11.73**	-6.52**	-16.19**	-9.06**
43	RK 8604 x Vaibhav	-7.09**	-1.83*	-4.29**	-1.07	-5.69**	-1.45**
44	RK 8605 x Vaibhav	-1.43	4.51**	-0.96	2.48**	-1.19	3.49**
45	RK 8608 x Vaibhav	2.24*	9.62**	5.60**	5.48**	3.92**	7.55**
46	RK 8701 x Vaibhav	7.24**	20.06**	3.93**	11.26**	5.59**	15.66**
47	RK 8702 x Vaibhav	5.35**	-5.61**	2.82*	-3.07**	4.09**	-4.34**
48	RK 8801 x Vaibhav	20.68**	2.28**	11.38**	1.26*	16.03**	1.77**
49	RK 8802 x Vaibhav	-1.32	-8.61**	-1.07	-4.85**	-1.19	-6.73**
50	RK 8803 x Vaibhav	1.68	-7.49**	0.60	-4.29*	1.15	-5.89**
51	RK 8901 x Vaibhav	-0.21	5.51**	-0.62	3.26**	-0.41	4.38**
52	RK 8902 x Vaibhav	-1.21	3.95**	-0.73	2.26**	-0.97	3.11**
53	RK 8903 x Vaibhav	20.46**	-7.61**	11.38**	-4.52**	15.92**	-6.06**
54	RK 9001 x Vaibhav	-22.76**	-2.16*	-12.73**	-1.18*	-17.75**	-1.67**
55	RK 9002 x Vaibhav	8.13**	-1.94*	4.38**	-1.52**	6.25**	-1.73**
56	RK 918506 x Vaibhav	-2.87**	0.73	-1.96	0.59	-2.41**	6.66
57	RK 911296 x Vaibhav	-2.09	-1.38	-1.29	-0.74	-1.69	-1.06*
58	RK 9 x Vaibhav	2.79**	0.51	1.38	0.26	2.09*	0.38
59	RK 14 x Vaibhav	5.57**	-1.05	3.04*	-0.52	4.31**	-0.78
60	KRV47 x Vaibhav	9.02**	0.51	4.71**	0.37	6.86**	0.44
	SE ($\hat{S}_{ij}$)	1.09	0.91	1.32	0.55	0.85	0.53

Table 7: Contd.

S. No.	Crosses	Leaf water potential					
		Normal Sown(E_1)		Late Sown(E_2)		Pooled	
		F_1	F_2	F_1	F_2	F_1	F_2
1	RK 8601x M. Rai	-0.59	1.44**	-0.28	0.61	-0.43	1.02**
2	RK8602 x M. Rai	-0.74	3.63**	-0.35	1.62**	-0.54	2.63**
3	RK8604 x M. Rai	1.21*	1.05**	+0.56	0.43	0.88**	0.74**
4	RK8605 x M. Rai	0.95	0.10	0.44	0.14	0.70*	0.12
5	RK8608 x M. Rai	1.77**	0.83	0.87**	0.43	1.32**	0.63**
6	RK8701 x M. Rai	0.71	-2.71**	0.33	-1.33**	0.52	-2.02**
7	RK8702 x M. Rai	-1.55**	-0.79	-0.72*	-0.43	-1.14**	-0.61*
8	RK8801 x M. Rai	0.53	1.50**	-0.20	0.63	0.17	1.07**
9	RK8802 x M. Rai	-5.15**	0.60	-3.07**	0.22	-4.11**	0.41
10	RK8803 x M. Rai	-2.02**	-1.09**	-0.94**	-0.57	-1.48**	-0.83**
11	RK8901 x M. Rai	-0.83	3.14**	-0.39	1.40**	-0.61*	2.27**
12	RK8902 x M. Rai	0.50	-2.16**	0.23	-1.07**	0.37	-1.61**
13	RK8903 x M. Rai	0.97	-1.16**	1.56**	-0.61	1.26**	-0.89**
14	RK9001 x M. Rai	-4.36**	-4.20*	-2.03**	-2.02**	-3.19**	-3.11**
15	RK9002 x M. Rai	4.15**	-1.96**	1.93**	-0.98**	3.04**	-1.47**
16	RK918506 x M. Rai	2.62**	-4.62**	1.22**	-2.21**	1.92**	3.41**
17	RK 911296 x M.Rai	-3.50**	1.82**	-1.63**	0.78**	-2.57**	1.30**
18	RK 9 x M. Rai	1.52**	-0.45	0.71*	0.27	1.12**	-3.36**
19	RK 14 x M. Rai	-0.49	3.30**	-0.23	1.47**	-0.36	2.39**
20	KRV 47 x M. Rai	4.28**	1.72**	1.99**	1.76**	3.14**	1.74**
21	RK8601 x Laha 101	0.75	-3.03**	0.26	-1.30**	0.51	-2.17
22	RK8602 x Laha 101	0.96	-1.78**	0.36	-0.72*	0.66*	-1.25
23	RK 8604 x Laha 101	0.21	-0.45	0.02	-0.10	0.12	0.28
24	RK8605 x Laha 101	-2.83**	1.93**	-1.40**	1.16**	-2.12**	1.53**
25	RK8608 x Laha 101	-1.52**	-1.26**	-0.74*	-0.70*	-1.13**	-0.98**
26	RK8701 x Laha 101	0.30	2.04**	0.06	1.06**	0.18	1.53**
27	RK8702 x Laha 101	-1.28**	2.12**	-0.68*	1.09**	-0.98**	1.60**
28	RK8801x Laha 101	-1.13*	-0.40	-0.39	-0.08	-0.76**	-0.24
29	RK8802 x Laha 101	1.50**	0.14	0.94**	0.17	1.22**	0.15
30	RK8803 x Laha 101	1.40**	2.17**	0.56	1.12**	0.98**	1.65**
31	RK 8901 x Laha 101	1.82**	-2.91**	0.76**	-1.25**	1.29**	-2.08**
32	RK 8902 x Laha 101	-4.45**	-1.95**	-2.16**	-0.80*	-3.30**	-1.38**
33	RK 8903 x Laha 101	-3.54**	0.17	-0.62*	0.18	-2.08**	0.18
34	RK 9001 x Laha 101	0.59	3.57**	0.19	1.77**	0.39	2.67**
35	RK 9002 x Laha 101	0.05	-2.34**	-0.06	-0.98**	-0.01	-1.66**
36	RK 918506x Laha 101	2.21**	0.81	0.94**	0.48	1.57**	0.64*
37	RK911296 x Laha 101	6.31**	0.36	2.85**	0.27	4.58**	0.32
38	RK 9 x Laha 101	2.73**	0.26	1.18**	0.23	1.96**	0.24
39	RK 14 x Laha 101	-0.85	-0.09	-0.48	0.06	-0.67*	-0.01
40	KRV47 x Laha 101	-3.24**	0.66	-1.59**	-1.63**	-2.41**	-0.49
41	RK8601 x Vaibhav	-0.16	1.59--	0.01	0.70	-0.07	1.14**
42	RK8602 x Vaibhav	-0.22	-1.85**	-0.01	-0.90**	-0.12	-1.37**
43	RK 8604 x Vaibhav	-1.42**	-0.60	-0.57	-0.32	-1.00**	-0.46
44	RK 8605 x Vaibhav	1.88**	-2.04**	0.98**	-1.30**	1.42**	-1.67**
45	RK 8608 x Vaibhav	-0.26	0.43	1.14	0.27	-0.20	0.35
46	RK 8701 x Vaibhav	-1.02*	0.67	-0.38	0.27	-0.70*	0.47
47	RK 8702 x Vaibhav	2.83**	-1.32**	1.41**	-0.66*	2.12**	-0.99**
48	RK 8801 x Vaibhav	0.60	-1.10**	0.59	-0.55	0.60*	-0.85**
49	RK 8802 x Vaibhav	3.65**	-0.74	3.12**	-0.38	2.89**	-0.56*
50	RK 8803 x Vaibhav	0.62	-1.08**	0.38	-0.55	0.50	-0.82**
51	RK 8901 x Vaibhav	-0.99	-0.23	-0.37	-0.15	-0.68*	-0.19
52	RK 8902 x Vaibhav	3.95**	4.11**	1.93**	1.87**	2.94**	2.99**
53	RK 8903 x Vaibhav	2.57**	1.00*	-0.94**	0.42	0.81**	0.71**
54	RK 9001 x Vaibhav	3.77**	0.63	1.84**	0.25	2.81**	0.44
55	RK 9002 x Vaibhav	-4.20**	4.30**	-1.87**	1.96**	-3.03**	3.13**
56	RK 918506 x Vaibhav	-4.83**	3.81**	-2.16**	1.73**	-3.49**	2.77**
57	RK 911296 x Vaibhav	-2.81**	-2.18**	-1.22**	-1.06**	-2.01**	1.62**
58	RK 9 x Vaibhav	-4.26**	0.19	-1.89**	0.05	-3.07**	0.12
59	RK 14 x Vaibhav	1.34**	-3.21**	0.71*	-1.54**	1.03**	-2.37**
60	KRV47 x Vaibhav	-1.05*	-2.38**	0.40	-0.12	-0.72**	-1.25**
	SE ($\hat{S}_{ij}$)	0.50	0.42	0.30	0.33	0.29	0.27

Table 7: Contd.

S. No.	Crosses	Yield per plant					
		Normal Sown(E_1)		Late Sown(E_2)		Pooled	
		F_1	F_2	F_1	F_2	F_1	F_2
1	RK 8601x M. Rai	7.35**	-6.95**	3.75**	-3.47**	5.55**	-5.21**
2	RK8602 x M. Rai	0.63	-2.64**	0.32	-1.27**	0.48	-1.95**
3	RK8604 x M. Rai	-2.24**	-4.24**	1.14**	-2.09**	-1.69**	-3.18**
4	RK8605 x M. Rai	-2.13**	-5.69**	-1.11**	-2.81**	-4.62**	-4.25**
5	RK8608 x M. Rai	8.43**	1.87*	-4.29**	1.03*	-6.36**	1.45**
6	RK8701 x M. Rai	2.61**	0.01	1.34**	0.08	1.98**	0.05
7	RK8702 x M. Rai	1.83**	7.37**	0.93**	3.82**	1.38**	5.60**
8	RK8801 x M. Rai	-1.67**	7.88**	-0.85**	4.24**	-1.26**	6.06**
9	RK8802 x M. Rai	-3.24**	4.02**	-1.66**	2.16**	-2.45**	3.09**
10	RK8803 x M. Rai	-0.63	5.31**	-0.29	2.72**	-0.46	4.02**
11	RK8901 x M. Rai	6.60**	1.69	3.38**	-0.76	4.99**	0.47
12	RK8902 x M. Rai	5.70**	6.22**	2.91**	3.27**	4.30**	4.75**
13	RK8903 x M. Rai	2.70**	2.81**	1.38**	1.51**	2.04**	2.16**
14	RK9001 x M. Rai	-0.95	-8.21**	-0.50	-4.10**	-0.72**	-6.15**
15	RK9002 x M. Rai	-7.60**	-3.82**	-3.88**	-1.87**	-5.74**	-2.84**
16	RK918506 x M. Rai	7.02**	-3.69**	3.58**	1.80**	5.30**	-2.70**
17	RK 911296 x M.Rai	1.96**	-2.14**	1.01**	-1.01*	1.49**	-1.38**
18	RK 9 x M. Rai	-6.17**	-6.99**	-3.15**	-3.50**	-4.66**	-5.24**
19	RK 14 x M. Rai	-4.39**	+0.80	-2.26**	0.47	-3.32**	0.63
20	KRV 47 x M. Rai	1.03	6.42**	0.53	3.37**	0.78**	4.90**
21	RK8601 x Laha 101	-9.43**	-2.09**	-4.84**	-1.24**	-7.12**	-1.67**
22	RK8602 x Laha 101	2.41**	3.15**	1.22**	1.46**	1.81**	2.31**
23	RK 8604 x Laha 101	1.88**	-0.51	0.96**	-0.43	1.42**	-0.47
24	RK8605 x Laha 101	3.79**	0.61	1.95**	0.15	2.87**	0.38
25	RK8608 x Laha 101	6.32**	-0.90	3.20**	-0.64	4.76**	-0.77
26	RK8701 x Laha 101	-10.68**	5.08**	-5.46**	2.44**	-8.07**	3.76**
27	RK8702 x Laha 101	1.11*	-10.97**	0.56*	-5.75**	0.84**	-8.36**
28	RK8801x Laha 101	2.45**	-3.32**	1.25**	-1.93**	1.85**	-2.63**
29	RK8802 x Laha 101	8.28**	2.72**	4.24**	1.21**	6.26**	1.97**
30	RK8803 x Laha 101	-6.71**	2.31**	-3.43**	0.98*	-5.07**	1.64**
31	RK 8901 x Laha 101	-9.59**	1.59	-4.96**	4.04**	-7.24**	2.81**
32	RK 8902 x Laha 101	-4.62**	-8.15**	2.33**	-4.34**	-3.47**	-6.24**
33	RK 8903 x Laha 101	4.95**	-0.09	2.54**	-0.20	3.74**	-0.14
34	RK 9001 x Laha 101	3.47**	3.49**	1.76**	1.59**	2.61**	2.54**
35	RK 9002 x Laha 101	7.31**	4.68**	3.75**	2.23**	5.53**	3.45**
36	RK 918506x Laha 101	-1.96**	4.58**	-1.00**	2.16**	-1.48**	3.35**
37	RK911296 x Laha 101	-6.12**	-1.68	-3.13**	-1.02*	-4.62**	-1.35**
38	RK 9 x Laha 101	4.95**	6.18**	2.52**	2.99**	3.73**	4.58**
39	RK 14 x Laha 101	-0.54	-1.44	-0.26	-0.87	-0.40	-1.16*
40	KRV47 x Laha 101	2.71**	-5.18**	1.39**	-2.81**	2.05**	-3.99**
41	RK8601 x Vaibhav	2.08**	9.05**	1.07**	4.71**	1.57**	6.88**
42	RK8602 x Vaibhav	-3.04**	-0.51	-1.53**	-0.19	-2.29**	-0.35
43	RK 8604 x Vaibhav	0.36	4.79**	0.18	2.52**	0.27	3.65**
44	RK 8605 x Vaibhav	-1.67**	5.08**	-0.83**	2.66**	-1.25**	3.87**
45	RK 8608 x Vaibhav	2.10**	-0.97	1.09**	-0.39	1.59**	-0.68
46	RK 8701 x Vaibhav	8.07**	-5.09**	4.12**	-2.57**	6.09**	-3.80**
47	RK 8702 x Vaibhav	-2.94**	3.60**	-1.49**	1.93**	-2.22**	2.77**
48	RK 8801 x Vaibhav	-0.78	-4.55**	-0.40	-2.31**	-0.59*	-3.43**
49	RK 8802 x Vaibhav	-5.04**	-6.74**	-2.58**	-3.37**	-3.81**	-5.16**
50	RK 8803 x Vaibhav	7.33**	-7.63**	3.72**	3.70**	5.53**	-5.66**
51	RK 8901 x Vaibhav	2.99**	3.21**	1.52**	-3.28**	2.25**	-3.28**
52	RK 8902 x Vaibhav	-1.08*	1.92*	-0.58*	1.08*	-0.83**	1.50**
53	RK 8903 x Vaibhav	-7.64**	-2.72**	-3.91**	-1.31**	-5.78**	-2.02**
54	RK 9001 x Vaibhav	-2.52**	4.72**	-1.26**	2.51**	-1.89**	3.62**
55	RK 9002 x Vaibhav	0.29	-0.85	0.13	-0.36	0.21	-0.61
56	RK 918506 x Vaibhav	-3.06**	-0.85	-2.58**	-0.36	-3.82**	-0.61
57	RK 911296 x Vaibhav	4.16**	3.82**	2.12**	+2.03	3.14**	2.93**
58	RK 9 x Vaibhav	1.22*	0.81	0.63*	0.51	0.93**	0.66
59	RK 14 x Vaibhav	4.93**	0.63	2.52**	0.41	3.73**	0.52
60	KRV47 x Vaibhav	-3.74**	-1.24	-1.92**	-0.56	-0.83**	-0.90
	SE ($\hat{S}_{ij}$)	0.52	0.85	0.27	0.44	0.29	0.48

Table 7: Contd.

S. No.	Crosses	Oil content					
		Normal Sown(E_1)		Late Sown(E_2)		Pooled	
		F_1	F_2	F_1	F_2	F_1	F_2
1	RK 8601x M. Rai	0.27**	-0.07	0.33**	-0.08	0.30**	-0.07
2	RK8602 x M. Rai	-0.22**	0.38**	-0.27**	0.48**	-0.25**	0.43**
3	RK8604 x M. Rai	-0.15**	-0.34**	-0.18**	-0.43**	-0.17**	-0.39**
4	RK8605 x M. Rai	-0.17**	-0.36**	-0.21**	-0.46**	-0.19**	-0.41**
5	RK8608 x M. Rai	0.07	-0.25**	0.09**	-0.31**	0.08**	-0.28**
6	RK8701 x M. Rai	0.21**	-0.47**	0.27**	-0.60**	0.24**	-0.53**
7	RK8702 x M. Rai	-0.02	-0.17**	-0.11**	-0.21**	-0.06**	-0.19**
8	RK8801 x M. Rai	-0.16**	0.01	-0.20**	0.01	-0.18*	0.01
9	RK8802 x M. Rai	-0.01	0.13**-	-0.02	0.16**	-0.01	0.15**
10	RK8803 x M. Rai	0.13**	-0.01	0.17**	-0.01	0.15**	-0.01
11	RK8901 x M. Rai	-0.04	0.02	-0.04	0.28**	-0.04	0.25**
12	RK8902 x M. Rai	0.03	0.20**	0.05	0.26**	0.04	0.23**
13	RK8903 x M. Rai	0.09*	-0.20**	0.12**	-0.24**	0.11**	-0.22**
14	RK9001 x M. Rai	-0.01	0.41**	0.04	0.49**	0.02	0.45**
15	RK9002 x M. Rai	0.04	0.36**	0.06	0.46**	0.05	0.41**
16	RK918506 x M. Rai	-0.05	0.28**	-0.05	0.35**	-0.05	0.31**
17	RK 911296 x M.Rai	0.02	-0.32**	0.03	-0.40**	0.03	0.36**
18	RK 9 x M. Rai	-0.15**	0.01	-0.19**	0.02	-0.17**	0.01
19	RK 14 x M. Rai	-0.33**	0.02	-0.41**	-0.02	-0.37**	0.00
20	KRV 47 x M. Rai	0.42**	0.18**	0.53**	0.25**	0.47**	0.21**
21	RK8601 x Laha 101	-0.12	0.86**	-0.13**	0.43**	-0.12**	0.39**
22	RK8602 x Laha 101	0.05	-0.01	0.07	-0.02	0.06*	-0.01
23	RK 8604 x Laha 101	-0.08	0.11**	-0.09*	0.13*	-0.08*	0.12**
24	RK8605 x Laha 101	0.20**	-0.06	0.26**	-0.08	0.03	-0.07
25	RK8608 x Laha 101	-0.25**	0.10**	-0.31**	0.12*	-0.28**	0.12**
26	RK8701 x Laha 101	0.00	0.38**	0.01	0.48**	0.01	0.43**
27	RK8702 x Laha 101	-0.13**	0.23**	-0.24**	0.28**	-0.18**	0.26**
28	RK8801x Laha 101	-0.03	0.39**	0.02	0.49**	-0.02	0.44**
29	RK8802 x Laha 101	0.12**	-0.13**	0.16**	-0.17**	0.14**	-0.15**
30	RK8803 x Laha 101	-0.06	0.11**	-0.06	0.14*	-0.06*	0.12**
31	RK 8901 x Laha 101	0.12**	-0.49**	0.15**	-0.62**	0.13**	-0.53**
32	RK 8902 x Laha 101	0.07	-0.16**	0.09*	0.21**	0.08**	-0.18**
33	RK 8903 x Laha 101	-0.08*	0.02	-0.10**	0.02	-0.09**	0.02
34	RK 9001 x Laha 101	0.10**	-0.61**	0.05	-0.75**	0.08**	-0.68*
35	RK 9002 x Laha 101	0.04	0.16**	0.05	0.20**	0.04	0.18**
36	RK 918506x Laha 101	0.01	0.03	0.00	0.03	0.01	0.03
37	RK911296 x Laha 101	0.02	-0.25**	0.03	-0.32**	0.03	-0.28**
38	RK 9 x Laha 101	0.01	0.06	0.03	0.08	0.02	0.07
39	RK 14 x Laha 101	0.01	-0.15**	0.03	-0.11	0.02	-0.13**
40	KRV47 x Laha 101	0.01	-0.08*	0.02	0.15**	0.01	-0.11**
41	RK8601 x Vaibhav	-0.15**	0.28**	-0.20**	-0.35**	-0.18**	-0.32**
42	RK8602 x Vaibhav	0.17**	-0.37**	0.21**	-0.47**	0.19**	-0.42**
43	RK 8604 x Vaibhav	0.23**	0.24**	0.28**	0.30**	0.25**	0.27**
44	RK 8605 x Vaibhav	-0.03	0.43**	-0.05	0.54**	-0.04	0.48**
45	RK 8608 x Vaibhav	0.19**	0.15**	0.22**	0.19**	0.20**	0.17**
46	RK 8701 x Vaibhav	-0.21**	0.08*	-0.28**	0.12*	-0.25**	0.10**
47	RK 8702 x Vaibhav	0.15**	-0.06	0.35**	-0.07	0.25**	-0.07
48	RK 8801 x Vaibhav	0.18**	-0.40**	0.22**	-0.50**	0.20**	-0.45**
49	RK 8802 x Vaibhav	-0.10**	0.01	-0.14**	0.01	-0.12**	0.00
50	RK 8803 x Vaibhav	-0.08*	-0.10**	-0.11**	-0.13*	-0.09**	0.12**
51	RK 8901 x Vaibhav	0.08*	0.26**	-0.11**	0.33**	-0.10**	0.30**
52	RK 8902 x Vaibhav	-0.10**	-0.04	-0.14**	-0.05	-0.12**	-0.04
53	RK 8903 x Vaibhav	-0.01	0.17**	-0.02	0.22**	-0.02	0.20**
54	RK 9001 x Vaibhav	-0.10**	0.20**	-0.09*	0.27**	-0.09**	0.23**
55	RK 9002 x Vaibhav	-0.08*	-0.52**	-0.11**	-0.65**	-0.09**	-0.59**
56	RK 918506 x Vaibhav	0.05	-0.30**	0.05	-0.39**	0.05	-0.35**
57	RK 911296 x Vaibhav	-0.04	0.57**	-0.06	0.71**	-0.05	0.35**
58	RK 9 x Vaibhav	0.14**	-0.07	0.17**	-0.09	0.15**	-0.08*
59	RK 14 x Vaibhav	0.31**	0.13**	0.38**	0.14*	0.35**	0.13**
60	KRV47 x Vaibhav	-042**	-0.09*	-0.55**	-0.10	-0.48**	-0.10**
	SE ($\hat{S}_{ij}$)	0.04	0.04	0.04	0.06	0.03	0.04

Table 7: Contd.

S. No.	Crosses	Euric acid					
		Normal Sown(E_1)		Late Sown(E_2)		Pooled	
		F_1	F_2	F_1	F_2	F_1	F_2
1	RK 8601x M. Rai	-0.45	0.08	0.10	-0.04	-0.17	0.02
2	RK8602 x M. Rai	-0.03	0.05	0.14	-0.02	0.06	0.01
3	RK8604 x M. Rai	0.48	-0.12	-0.24	0.06	0.12	-0.03
4	RK8605 x M. Rai	0.17	0.06	0.21	0.14	0.19	-0.04
5	RK8608 x M. Rai	-0.03	0.07	-0.07	0.19	-0.05	0.13
6	RK8701 x M. Rai	-0.14	-0.13	-0.14	-0.04	-0.14	-0.09
7	RK8702 x M. Rai	-0.23	0.06	0.44	-0.04	0.10	0.01
8	RK8801 x M. Rai	0.19	0.07	0.16	0.29	0.18	0.18
9	RK8802 x M. Rai	0.05	-0.13	-0.60	-0.25	-0.28	-0.19
10	RK8803 x M. Rai	0.41	-0.14	-0.36	-0.04	0.02	-0.09
11	RK8901 x M. Rai	-1.15*	0.17	0.05	-0.02	-0.55	0.08
12	RK8902 x M. Rai	0.74	-0.03	0.31	0.06	0.53	0.02
13	RK8903 x M. Rai	0.38	-0.25	1.00	-0.04	0.69	-0.14
14	RK9001 x M. Rai	-0.13	0.07	0.04	-0.02	-0.05	0.02
15	RK9002 x M. Rai	-0.25	0.18	-1.04	0.06	-0.64	0.12
16	RK918506 x M. Rai	0.07	0.06	-0.25	-0.14	-0.09	-0.04
17	RK 911296 x M.Rai	0.18	0.38	0.16	-0.12	0.17	0.13
18	RK 9 x M. Rai	-0.25	-0.44	0.09	0.27	-0.08	-0.09
19	RK 14 x M. Rai	-0.55	-0.25	0.33	-0.04	-0.11	-0.14
20	KRV 47 x M. Rai	0.49	0.07	0.37	-0.02	0.43	0.02
21	RK8601 x Laha 101	0.06	8.18**	-0.70	0.06	-0.32	0.12
22	RK8602 x Laha 101	0.07	-0.14	-0.33	0.40	-0.13	0.13
23	RK 8604 x Laha 101	0.18	0.17	-0.30	-0.24	-0.06	-0.03
24	RK8605 x Laha 101	-0.25	-0.03	0.63	-0.16	0.19	-0.10
25	RK8608 x Laha 101	-0.08	-0.04	-0.46	-0.04	-0.27	-0.04
26	RK8701 x Laha 101	0.10	-0.04	0.27	-0.02	0.18	0.03
27	RK8702 x Laha 101	-0.02	0.07	0.19	0.06	0.09	0.07
28	RK8801x Laha 101	-0.04	0.27	0.44	-0.14	0.20	0.06
29	RK8802 x Laha 101	0.08	-0.04	-0.53	0.19	0.23	0.08
30	RK8803 x Laha 101	-0.04	-0.24	0.09	-0.04	0.02	-0.14
31	RK 8901 x Laha 101	0.38	-0.14	0.13	0.97	0.25	0.41
32	RK 8902 x Laha 101	-0.13	0.17	-0.53	-0.68	-0.33	-0.25
33	RK 8903 x Laha 101	-0.25	-0.03	0.40	-0.29	0.08	-0.16
34	RK 9001 x Laha 101	-0.14	0.27	0.75	-0.14	0.30	0.06
35	RK 9002 x Laha 101	-0.03	-0.04	0.16	0.19	0.07	0.08
36	RK 918506x Laha 101	0.17	-0.24	-0.91	-0.04	-0.37	-0.14
37	RK911296 x Laha 101	0.27	-1.05**	-0.82	-0.16	-0.27	-0.60
38	RK 9 x Laha 101	0.08	-1.04**	-0.40	0.20	-0.16	-0.42
39	RK 14 x Laha 101	-0.35	2.09**	1.22*	-0.04	0.43	1.03
40	KRV47 x Laha 101	-0.14	-0.17	-0.02	-0.04	-0.08	0.06
41	RK8601 x Vaibhav	-0.03	-0.14	-0.30	-0.02	-0.16	-0.08
42	RK8602 x Vaibhav	0.17	-0.03	-0.32	0.06	0.24	0.01
43	RK 8604 x Vaibhav	-0.04	0.06	0.23	-0.04	0.10	0.01
44	RK 8605 x Vaibhav	0.08	0.06	-0.73	-0.02	-0.33	0.02
45	RK 8608 x Vaibhav	-0.04	-0.12	-0.50	-0.06	0.23	-0.03
46	RK 8701 x Vaibhav	0.07	0.06	-0.02	-0.04	0.02	0.01
47	RK 8702 x Vaibhav	-0.13	0.07	-0.30	-0.02	-0.21	0.02
48	RK 8801 x Vaibhav	0.06	-0.13	0.32	0.06	0.19	-0.04
49	RK 8802 x Vaibhav	0.07	0.37	-1.00	0.06	-0.47	0.22
50	RK 8803 x Vaibhav	-0.13	0.07	1.04	0.09	0.45	0.08
51	RK 8901 x Vaibhav	0.06	-0.44	-0.04	-0.15	0.01	-0.29
52	RK 8902 x Vaibhav	0.24	-0.24	0.33	-0.16	0.05	-0.19
53	RK 8903 x Vaibhav	0.18	0.07	0.37	-0.12	0.27	-0.02
54	RK 9001 x Vaibhav	0.06	0.17	-0.70	0.27	-0.32	0.22
55	RK 9002 x Vaibhav	0.07	0.51	-0.99	0.06	-0.46	0.29
56	RK 918506 x Vaibhav	0.18	-0.15	1.33*	0.09	0.75	-0.03
57	RK 911296 x Vaibhav	-0.25	-0.35	-0.34	-0.15	-0.29	-0.25
58	RK 9 x Vaibhav	-0.04	0.27	0.31	-0.25	0.14	0.01
59	RK 14 x Vaibhav	0.08	-0.04	-0.96	0.09	-0.44	0.02
60	KRV47 x Vaibhav	-0.04	-0.24	0.65	0.16	0.31	-0.04
	SE ($\hat{S}_{ij}$)	0.54	0.32	0.61	1.14	0.43	0.59

*** Significant at p = 0.05 ; ** Significant at p = 0.01**

Table 8a: Estimates of economic heterosis in two environments [normal sown (E_1) and late sown (E_2)] alongwith pooled values for 13 characters in 60 F_1 s of Indian mustard

		Economic heterosis over best parent					
		Days to flowering			Days to reproductive phase		
S.N.	Crosses	E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	2.52	2.80	2.66	0.00	16.93**	8.47
2.	RK8602 x Mathura Rai	-8.41	-6.56*	-7.49*	5.37	21.87**	13.62
3.	RK8604 x Mathura Rai	-15.12*	-12.16**	-13.64*	8.07*	25.16**	16.62*
4.	RK8605 x Mathura Rai	-14.29*	-11.21**	-12.75*	3.46	20.22**	11.84
5.	RK8608 x Mathura Rai	-15.12*	-11.21**	-13.17*	3.06	20.22**	11.64
6.	RK8701 x Mathura Rai	-10.94	-11.21**	-11.08	-4.61	13.09*	4.47
7.	RK8702 x Mathura Rai	-14.29*	-12.16**	-13.23*	-3.85	13.63*	4.76
8.	RK8801 x Mathura Rai	-15.12*	-11.21**	-13.17*	-1.15	16.38**	7.62
9.	RK8802 x Mathura Rai	-12.60	-9.36**	-10.98	2.30	19.68**	10.99
10.	RK8803 x Mathura Rai	-10.08	-8.41**	-9.25	-3.46	13.63*	5.09
11.	RK8901 x Mathura Rai	-18.50**	-14.97**	-16.74**	-3.85	13.63*	4.89
12.	RK8902 x Mathura Rai	-13.46	-11.21**	-12.34*	2.86	19.68**	11.27
13.	RK8903 x Mathura Rai	-9.25	-7.48*	8.37*	-0.77	16.38**	7.81
14.	RL9001 x Mathura Rai	1.66	1.85	1.76	11.53**	29.56**	20.55**
15.	RK9002 x Mathura Rai	-15.98*	-12.16**	-14.07*	7.30	24.06**	15.68*
16.	RK918506 x Mathura Rai	-5.04	-3.75	-4.40	0.00	27.38**	13.69*
17.	RK911296 x Mathura Rai	-13.46	-11.21*	-12.34*	0.76	27.91**	14.34
18.	RK9 x Mathura Rai	-4.20	-3.75	-3.98	6.42	23.85**	15.14
19.	RK14 x Mathura Rai	-8.41	-6.56*	-7.49	2.30	19.12**	10.71
20.	KRV 47 x Mathura Rai	-10.08	-8.41**	-9.25*	6.53	23.85**	15.19
21.	RK8601 x Laha 101	-10.08	-7.48*	-8.78	3.06	20.22**	11.64
22.	RK8602 x Laha 101	-14.29*	-11.21**	-12.75*	3.46	20.22**	11.84
23	RK8604 x Laha 101	-2.52	-1.87	-2.20	-0.39	16.38**	7.99
24	RK8605 x Laha 101	-17.64**	-13.09**	-15.37**	10.76**	27.91**	19.34**
25	RK8608 x Laha 101	-12.60	-10.28**	-11.44	6.53	22.43**	14.48
26.	RK8701 x Laha 101	-3.37	-1.87	-2.62	8.83*	25.70**	17.27*
27.	RK8702 x Laha 101	-5.89	-4.68	-5.29	4.61	21.32**	12.97
28.	RK8801 x Laha 101	-3.37	-1.87	-2.62	-3.46	30.10**	8.32
29.	RK8802 x Laha 101	-10.08	-8.41**	-9.25	1.91	19.12**	10.52
30.	RK8803 x Laha 101	-11.77	-1.87	-6.82	0.00	27.35**	13.68
31.	RK8901 x Laha 101	-0.85	10.26**	4.71	3.46	20.22**	11.84*
32.	RK8902 x Laha 101	-6.73	3.72	-1.51	-3.85	30.10**	13.13
33.	RK8903 x Laha 101	-5.89	4.65	-0.62	9.99**	26.81**	18.40**
34.	RL9001 x Laha 101	9.22	21.47**	15.35	5.76	22.41**	14.09
35.	RK9002 x Laha 101	-7.56	2.80	-2.38	-0.77	16.30**	7.77
36.	RK918506 x Laha 101	7.56	2.80	-2.38	11.53**	28.45**	19.99**
37.	RK911296 x Laha 101	-5.89	2.80	-1.55	8.83	25.75**	17.29
38.	RK9 x Laha 101	-10.08	0.00	-5.04	5.37	21.87**	13.62
39.	RK14 x Laha 101	-15.98*	-6.56**	-11.27*	3.06	20.22**	11.64
40.	KRV 47 x Laha 101	-10.94	-0.95	-5.95	5.76	22.45**	14.11
41.	RK8601 xVaibhav	-3.37	7.45*	2.04	9.61**	26.26**	15.94**
42.	RK8602 xVaibhav	-0.85	9.95**	4.55	12.29**	22.97**	17.63**
43.	RK8604 xVaibhav	-0.85	10.26**	4.71	0.00	17.47**	8.74
44	RK8605 xVaibhav	-2.52	8.41**	2.94	4.61	21.32**	12.97
45.	RK8608 xVaibhav	-11.77	12.13**	0.18	2.68	20.22**	11.45
46.	RK8701 xVaibhav	3.35	14.94**	9.15	8.07*	25.16**	16.62*
47.	RK8702 xVaibhav	-14.29*	-4.68	-9.49	2.30	17.47**	9.89
48.	RK8801 xVaibhav	-1.68	9.33**	3.82	-3.07	14.17**	5.55
49.	RK8802 xVaibhav	-6.73	3.72	-1.51	2.30	19.68**	10.99
50.	RK8803 xVaibhav	5.04	16.82**	10.93	8.07*	25.16**	16.62**
51.	RK8901 xVaibhav	4.18	15.86**	10.02	11.14**	27.91**	19.53**
52.	RK8902 xVaibhav	-6.73	2.80	-1.97	5.37	21.87**	13.62
53.	RK8903 xVaibhav	-10.08	0.00	-5.04	6.92	23.85**	15.39
54.	RL9001 xVaibhav	-12.60	-2.80	-7.70	10.76**	27.35**	19.06**
55.	RK9002 xVaibhav	-9.25	0.92	-4.17	10.76**	27.35**	19.06**
56.	RK918506 xVaibhav	-12.60	-2.80	-7.70	8.07*	24.62**	16.35*
57.	RK911296 xVaibhav	4.18	15.86**	10.02	0.76	17.49**	8.75
58.	RK9 x Vaibhav	-0.85	10.26**	4.71	-3.08	14.17**	5.55
59.	RK14 xVaibhav	-20.16**	-5.60	-12.88	5.76	22.97**	14.37
60.	KRV 47 xVaibhav	-15.98*	-6.56*	-11.27*	8.83*	25.70**	17.27*
	SE [Diff. ≅(+)]	3.26	1.09	3.16	3.26	3.73	3.53

Table 8a: Contd.

		Economic heterosis over best parent					
		Number of primary branches			Number of Secondary branches		
S.N.	Crosses	E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	21.21	14.99	18.10	97.36**	84.54**	90.95**
2.	RK8602 x Mathura Rai	21.21	14.99	18.10	95.19**	84.54**	89.86**
3.	RK8604 x Mathura Rai	51.51**	43.74*	47.62*	64.67**	57.67**	61.17**
4.	RK8605 x Mathura Rai	11.06	5.34	8.20	34.99**	30.68*	32.83**
5.	RK8608 x Mathura Rai	76.81**	67.76**	72.28**	136.84**	126.87**	131.85**
6.	RK8701 x Mathura Rai	16.21	10.27	13.24	44.33**	30.68**	37.50**
7.	RK8702 x Mathura Rai	-4.09	-9.03	-6.56	18.42*	15.34	16.88
8.	RK8801 x Mathura Rai	56.51**	48.46**	52.48**	71.05**	65.28**	68.16**
9.	RK8802 x Mathura Rai	66.66**	58.11**	62.38**	36.15**	30.68**	33.41**
10.	RK8803 x Mathura Rai	6.06	0.62	3.34	44.33**	38.41**	41.37**
11.	RK8901 x Mathura Rai	36.36*	29.36	32.86	49.14**	42.41**	45.77**
12.	RK8902 x Mathura Rai	-9.09	-13.76	-11.42	55.72**	49.94**	52.83**
13.	RK8903 x Mathura Rai	51.51**	43.74**	47.62*	60.30**	57.67**	58.98**
14.	RL9001 x Mathura Rai	56.51**	48.44**	52.47**	38.15**	30.68**	34.41**
15.	RK9002 x Mathura Rai	-25.24	28.13	1.44	18.42*	15.34	16.88
16.	RK918506 x Mathura Rai	21.21	14.99	18.10	22.82**	15.34	19.08
17.	RK911296 x Mathura Rai	11.06	5.34	8.20	25.00**	19.15*	22.07*
18.	RK9 x Mathura Rai	36.36**	29.36	32.86	103.195**	92.27**	98.11**
19.	RK14 x Mathura Rai	11.06	5.34	8.20	71.05**	65.28**	68.16**
20.	KRV 47 x Mathura Rai	11.06	5.34	8.20	64.47**	57.67**	61.07**
21.	RK8601 x Laha 101	21.21	14.99	18.10	46.91**	38.41**	42.66**
22.	RK8602 x Laha 101	36.36*	29.36	32.86	38.15**	30.68**	34.41*
23	RK8604 x Laha 101	-4.09	-1.08	-2.58	0.85	-3.92	-1.53
24	RK8605 x Laha 101	-9.09	-13.76	-11.42	-1.31	-3.92	-2.61
25	RK8608 x Laha 101	76.81**	67.76**	72.28**	136.84**	126.87**	131.85**
26.	RK8701 x Laha 101	-24.24	-28.13	-26.18	22.82**	19.14*	20.98*
27.	RK8702 x Laha 101	16.21	-28.13	-26.18	51.32**	42.21**	46.76**
28.	RK8801 x Laha 101	56.51**	47.84**	52.17**	150.00**	142.21**	146.10**
29.	RK8802 x Laha 101	6.06	0.62	3.34	14.01	7.61	10.81
30.	RK8803 x Laha 101	-19.24	-23.41	-21.32	-5.02	7.73	1.35
31.	RK8901 x Laha 101	6.06	0.62	3.34	64.47**	57.67**	61.07**
32.	RK8902 x Laha 101	36.36*	-8.82	13.77	68.88**	65.28**	67.08**
33.	RK8903 x Laha 101	6.06	0.62	3.34	65.00**	19.14*	42.07*
34.	RL9001 x Laha 101	21.21	14.99	18.10	22.82**	-15.34	3.74
35.	RK9002 x Laha 101	36.36*	29.36	32.86	38.15**	30.68**	34.41**
36.	RK918506 x Laha 101	-9.09	-13.76	-11.42	22.82**	15.34	19.08
37.	RK911296 x Laha 101	-9.09	-13.76	-11.42	44.74**	38.41**	41.57**
38.	RK9 x Laha 101	51.51**	43.74*	47.62*	84.21**	73.01**	78.61**
39.	RK14 x Laha 101	66.66**	58.11**	62.38**	114.93**	99.88**	107.40**
40.	KRV 47 x Laha 101	66.66**	39.01*	52.83*	64.47**	57.67**	61.07**
41.	RK8601 xVaibhav	86.81**	77.21**	82.01**	147.83**	138.41**	143.12**
42.	RK8602 xVaibhav	26.21	19.71	22.96	18.42*	15.34	16.08
43.	RK8604 xVaibhav	51.51**	43.74*	47.62*	112.69**	99.88**	106.28**
44	RK8605 xVaibhav	36.36*	29.36	32.86	53.49**	46.14**	49.81**
45.	RK8608 xVaibhav	51.51**	43.74*	47.62*	79.80**	73.01**	76.40**
46.	RK8701 xVaibhav	51.51**	43.74*	47.62*	29.41**	23.01**	26.21**
47.	RK8702 xVaibhav	76.81**	67.76**	72.28**	31.58**	26.87**	29.22**
48.	RK8801 xVaibhav	36.36*	29.36	32.86	35.99**	26.87**	31.43**
49.	RK8802 xVaibhav	36.36*	29.98	33.17	71.05**	65.28**	68.16**
50.	RK8803 xVaibhav	36.36*	77.21**	56.78*	18.42*	15.34	16.88
51.	RK8901 xVaibhav	-9.09	19.71	5.31	-1.31	-3.92	-2.61
52.	RK8902 xVaibhav	21.21	43.74*	32.47	14.14**	38.41**	26.27**
53.	RK8903 xVaibhav	-4.09	29.36	12.63	-3.49	-7.73	-5.61
54.	RL9001 xVaibhav	6.06	43.74*	24.90	-10.06	-11.53	-10.79
55.	RK9002 xVaibhav	21.21	43.74*	32.47	-3.49	-3.92	-3.70
56.	RK918506 xVaibhav	81.81**	67.76**	74.78**	16.25	11.53	13.89
57.	RK911296 xVaibhav	51.51**	29.36	40.43	42.56**	34.60**	38.58**
58.	RK9 x Vaibhav	31.36	29.36	30.36	7.43	3.81	5.62
59.	RK14 xVaibhav	51.51**	43.74*	47.62*	71.05**	61.48	66.26
60.	KRV 47 xVaibhav	56.51**	48.46**	52.48**	27.17**	19.14**	23.15**
	SE [Diff. ≅(+)]	1.10	0.87	0.70	1.38	0.78	0.79

Table 8a: Contd.

		Economic heterosis over best parent					
		Height of plant			Length of main fruiting branch		
S.N.	Crosses	E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	-4.59	-22.65**	-13.62	20.43**	11.39**	15.91**
2.	RK8602 x Mathura Rai	-6.43	-24.26**	-15.35	23.11**	13.15**	18.13**
3.	RK8604 x Mathura Rai	-6.20	-23.80**	-15.00	2.69	-5.26	-1.29
4.	RK8605 x Mathura Rai	11.26**	-11.21*	0.03	14.51**	7.02	10.77
5.	RK8608 x Mathura Rai	7.35	-13.96**	-3.31	-0.53	0.00	-0.26
6.	RK8701 x Mathura Rai	8.96*	-12.81*	-1.93	22.04**	13.15**	17.60**
7.	RK8702 x Mathura Rai	8.50*	-13.04*	-2.27	24.19**	14.92**	19.56**
8.	RK8801 x Mathura Rai	11.49**	-5.72	2.89	20.96**	11.39**	16.18**
9.	RK8802 x Mathura Rai	15.40**	-2.99	6.21	15.60**	7.89	11.75
10.	RK8803 x Mathura Rai	3.47	-16.47**	-6.50	-3.22	-5.26	-4.24
11.	RK8901 x Mathura Rai	14.02**	1.13	7.58	32.79**	21.05**	22.31**
12.	RK8902 x Mathura Rai	-0.68	-19.45**	-10.07	4.83	0.00	2.42
13.	RK8903 x Mathura Rai	12.18**	-10.29	0.95	34.40**	22.81**	28.61**
14.	RL9001 x Mathura Rai	13.10**	-1.37	5.87	23.66**	14.02**	18.79**
15.	RK9002 x Mathura Rai	10.80**	-3.13	3.84	26.33**	15.78**	21.06**
16.	RK918506 x Mathura Rai	15.63**	-7.78	3.93	27.53	2.28	12.92
17.	RK911296 x Mathura Rai	15.63**	-2.74	6.45	29.56**	28.07**	28.82**
18.	RK9 x Mathura Rai	11.03**	-0.91	5.06	26.33**	15.78**	21.06**
19.	RK14 x Mathura Rai	10.80**	-6.40	2.20	18.82**	10.52**	14.67**
20.	KRV 47 x Mathura Rai	14.25**	-3.43	5.41	29.03**	23.68**	26.36**
21.	RK8601 x Laha 101	-4.36	-22.88**	-13.62	10.75*	4.39	7.57
22.	RK8602 x Laha 101	12.64**	-5.03	3.81	29.03**	24.55**	26.79**
23	RK8604 x Laha 101	12.14**	-15.56**	-1.71	11.29*	4.39	7.84
24	RK8605 x Laha 101	12.64**	-5.26	3.69	29.56**	25.44**	27.50**
25	RK8608 x Laha 101	14.71**	17.16**	15.94**	-30.11**	28.07**	-1.02
26.	RK8701 x Laha 101	13.10**	-4.57	4.27	23.66**	14.89**	18.78**
27.	RK8702 x Laha 101	4.60	-15.78**	-5.59	0.00	-3.50	-1.75
28.	RK8901 x Laha 101	14.02**	1.13	7.58	6.45	1.84	4.15
29.	RK8802 x Laha 101	15.17**	-8.01	3.58	30.11**	21.92**	26.02**
30.	RK8901 x Laha 101	14.71**	-8.07	3.12	22.04**	13.15**	17.59**
31.	RK8901 x Laha 101	17.01**	-6.63	5.19	17.20**	7.89	12.55**
32.	RK8902 x Laha 101	8.27*	-13.27*	-2.50	23.56**	21.92**	25.74**
33.	RK8903 x Laha 101	11.26**	-5.95	2.66	23.56**	12.28**	17.92**
34.	RL9001 x Laha 101	3.44	-16.70**	-6.63	3.22	-0.86	1.18
35.	RK9002 x Laha 101	33.56**	5.25	19.41	41.40**	19.28**	30.34**
36.	RK918506 x Laha 101	-13.79**	-29.51**	-21.65**	-13.43**	-13.15**	-13.29**
37.	RK911296 x Laha 101	-0.22	-19.45**	-9.84	2.14	-0.86	0.64
38.	RK9 x Laha 101	13.79**	0.91	7.35	7.53	2.63	5.08
39.	RK14 x Laha 101	-8.04*	-25.17**	-16.61*	21.50**	13.15**	17.33**
40.	KRV 47 x Laha 101	11.95**	4.57	8.26	23.56**	14.02**	18.79
41.	RK8601 xVaibhav	12.18**	-10.29	0.95	15.04**	7.89	11.46
42.	RK8602 xVaibhav	-8.50*	-25.63**	17.07**	-8.59	-9.65*	-9.08
43.	RK8604 xVaibhav	7.35	-17.39**	-5.02	2.69	-1.65	0.52
44	RK8605 xVaibhav	14.71**	1.59	8.15	-1.08	-4.39	-2.74
45.	RK8608 xVaibhav	13.55**	14.64**	14.10**	6.45	1.76	4.11
46.	RK8701 xVaibhav	15.40**	-8.01	3.70	17.20**	9.65*	13.43*
47.	RK8702 xVaibhav	20.00**	-2.51	8.75	30.11**	23.68**	26.89**
48.	RK8801 xVaibhav	12.41**	20.59**	16.50**	6.45	0.86	3.66
49.	RK8802 xVaibhav	13.33**	16.01**	14.67**	1.61	-1.76	-0.08
50.	RK8803 xVaibhav	2.53	-17.39**	-7.43	26.88**	15.78**	21.33**
51.	RK8901 xVaibhav	17.01**	12.35**	14.68*	12.90**	0.00	6.45
52.	RK8902 xVaibhav	12.64**	-4.80	3.92	22.04**	12.28**	17.16**
53.	RK8903 xVaibhav	11.64**	-5.75	3.42	6.98	1.76	4.37
54.	RL9001 xVaibhav	12.63**	17.16**	14.90**	22.58**	2.63	12.61
55.	RK9002 xVaibhav	14.62**	16.70**	15.36**	3.75	-0.86	1.46
56.	RK918506 xVaibhav	13.79**	22.88**	18.34**	3.22	-24.55**	10.67
57.	RK911296 xVaibhav	11.95**	9.83	10.89	29.56**	22.87**	26.22**
58.	RK9 x Vaibhav	4.28	-16.24**	5.98	13.98**	6.13	10.03
59.	RK14 xVaibhav	13.10**	16.01**	14.56**	18.82**	10.52**	14.67**
60.	KRV 47 xVaibhav	11.26**	4.34	7.80	15.04**	7.89	12.78
	SE [Diff. ≅ (±)]	5.43	7.87	6.77	3.24	1.59	3.71

Table 8a: Contd.

		Economic heterosis over best parent					
		No. of siliquae on main fruiting branch			Days to maturity		
S.N.	Crosses	E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	15.80**	8.89	12.34*	-0.51	2.21	1.36
2.	RK8602 x Mathura Rai	15.09**	8.89	11.99*	-3.93	1.88	-1.03
3.	RK8604 x Mathura Rai	2.93	-3.79	0.43	-0.51	1.88	0.67
4.	RK8605 x Mathura Rai	13.66**	7.59	10.62*	-3.38	0.00	-1.69
5.	RK8608 x Mathura Rai	-12.22**	6.34	9.28*	-3.90	8.85**	2.47
6.	RK8701 x Mathura Rai	-13.51**	-18.98**	-16.24**	-7.81*	-4.75	-6.28*
7.	RK8702 x Mathura Rai	-13.51**	-18.98**	-16.24**	-8.33*	-4.73	-6.53*
8.	RK8801 x Mathura Rai	-4.20	-17.69**	-10.94*	-6.77*	-6.64**	-6.71*
9.	RK8802 x Mathura Rai	-6.34	-12.64*	-9.49	-3.64	0.00	-1.82
10.	RK8803 x Mathura Rai	-31.37**	-35.43**	-33.40**	-6.76*	-3.48	-5.12
11.	RK8901 x Mathura Rai	-2.78	-8.04	-5.41	-9.63*	-5.70*	-7.67*
12.	RK8902 x Mathura Rai	-11.36**	-16.44**	-13.90**	-3.64	-0.94	-2.29
13.	RK8903 x Mathura Rai	-9.92*	-16.44**	-13.18*	-4.68	-1.58	-3.13
14.	RL9001 x Mathura Rai	-42.97**	-2.50	-22.73*	7.03*	8.22**	7.63*
15.	RK9002 x Mathura Rai	12.95**	0.34	6.64*	-1.30	1.25	-0.03
16.	RK918506 x Mathura Rai	-2.05	-8.84	-5.44	-2.85	5.99*	4.42
17.	RK911296 x Mathura Rai	0.08	-7.59	-3.75	-4.69	3.79	-0.45
18.	RK9 x Mathura Rai	20.20**	45.83**	18.31**	1.82	3.78	2.80
19.	RK14 x Mathura Rai	-16.57**	10.14	-3.18*	-2.34	0.30	-1.02
20.	KRV 47 x Mathura Rai	10.79	-5.05	2.87	0.00	2.21	0.11
21.	RK8601 x Laha 101	-9.93*	-15.19**	-12.56*	-2.34	0.62	-0.86
22.	RK8602 x Laha 101	11.52**	5.08	8.30*	-3.38	-0.63	-2.01
23	RK8604 x Laha 101	-4.20	-7.59	-5.89	-0.78	0.31	-0.24
24	RK8605 x Laha 101	7.93	2.54	5.23	-2.60	3.17	2.89
25	RK8608 x Laha 101	42.25**	34.18**	38.21**	-0.78	1.26	0.24
26.	RK8701 x Laha 101	-12.07**	-17.69**	-14.88**	3.64	5.68*	4.66*
27.	RK8702 x Laha 101	-21.36**	-29.09**	-25.22**	0.00	2.21	1.11
28.	RK8801 x Laha 101	17.24**	10.14	13.69*	4.68	8.22**	6.45**
29.	RK8802 x Laha 101	19.39**	11.39*	15.39*	3.12	0.32	1.72
30.	RK8803 x Laha 101	1.50	-5.05	-1.77	-4.94	4.10	-0.42
31.	RK8901 x Laha 101	-7.08**	-12.64*	9.86*	0.78	2.83	1.81
32.	RK8902 x Laha 101	12.93**	6.34	9.63*	-6.25	7.27**	0.51
33.	RK8903 x Laha 101	15.12**	2.54	8.83*	3.64	5.37*	4.51
34.	RL9001 x Laha 101	12.07**	-17.69**	-2.81**	5.46	5.05*	5.26
35.	RK9002 x Laha 101	53.69**	44.32**	48.70**	-4.17	-0.99	-2.58
36.	RK918506 x Laha 101	32.96**	25.33**	29.14**	4.17	6.32**	5.25
37.	RK911296 x Laha 101	15.80**	8.89	12.34*	3.12	5.05*	4.09
38.	RK9 x Laha 101	20.80**	13.93*	17.36*	-0.78	1.26	0.24
39.	RK14 x Laha 101	41.54**	32.92**	37.23**	-4.17	-0.95	-2.56
40.	KRV 47 x Laha 101	12.22**	0.34	6.28*	-0.78	1.25	0.25
41.	RK8601 xVaibhav	34.39**	26.58**	30.48**	4.16	5.69*	4.93
42.	RK8602 xVaibhav	-4.93	-11.39*	-8.16	6.76*	7.90**	7.33
43.	RK8604 xVaibhav	15.80**	8.83	12.34*	1.56	1.57	1.57
44	RK8605 xVaibhav	19.39**	12.68*	16.03*	1.04	3.16	2.10
45.	RK8608 xVaibhav	14.37**	7.59	10.98**	0.78	3.16	1.97
46.	RK8701 xVaibhav	5.79	0.00	2.89	7.81*	6.95**	7.38*
47.	RK8702 xVaibhav	24.38**	17.73**	21.05**	-5.72	-2.54	-4.13
48.	RK8801 xVaibhav	12.95**	6.34	9.64*	-3.90	-0.64	-2.27
49.	RK8802 xVaibhav	-19.21**	-25.29**	-22.25**	-1.56	0.63	-1.09
50.	RK8803 xVaibhav	23.61**	16.48**	20.04**	5.73	7.58**	6.66*
51.	RK8901 xVaibhav	-18.51**	-24.04**	-21.27**	7.54*	8.85**	8.19*
52.	RK8902 xVaibhav	-2.79	-8.84	-5.81	0.00	2.21	1.11
53.	RK8903 xVaibhav	31.52**	22.78**	27.15**	0.26	2.21	1.24
54.	RL9001 xVaibhav	50.82**	41.77**	46.29**	2.08	4.10	3.09
55.	RK9002 xVaibhav	38.69**	30.36**	34.52**	-3.12	4.73	0.81
56.	RK918506 xVaibhav	-2.79	-10.10	-6.44	0.18	2.52	1.35
57.	RK911296 xVaibhav	16.51**	10.14	13.32*	0.51	2.84	1.68
58.	RK9 x Vaibhav	-19.21**	24.04**	2.41**	-3.64	-0.62	-2.13
59.	RK14 xVaibhav	9.37*	3.79	6.58	-2.07	0.62	-0.73
60.	KRV 47 xVaibhav	0.08	-6.30	-3.11	-0.26	2.20	-0.97
	SE [Diff. ≅(+)]	2.07	1.48	1.27	4.32	2.62	6.91

Table 8a: Contd.

		Economic heterosis over best parent					
		Relative water content			Leaf water potential		
S.N.	Crosses	E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	3.90**	3.87**	3.88**	7.86	25.83**	7.86
2.	RK8602 x Mathura Rai	-14.03**	-14.04**	-14.03**	-20.71**	-6.63	-13.71*
3.	RK8604 x Mathura Rai	-0.98	-0.96	-0.97	-20.71**	-7.28	-13.99*
4.	RK8605 x Mathura Rai	-3.52**	-3.52**	-3.52**	-22.85**	-9.93	16.39*
5.	RK8608 x Mathura Rai	-0.56	-0.59	-0.57	-5.00	11.92*	3.46
6.	RK8701 x Mathura Rai	-6.61**	-24.78**	-15.69**	6.42	24.50**	15.46*
7.	RK8702 x Mathura Rai	-5.51**	-5.51**	-5.51**	18.57**	-4.63	6.97
8.	RK8801 x Mathura Rai	0.08	-0.06	0.01	14.28**	0.66	7.47
9.	RK8802 x Mathura Rai	-1.54	1.54	0.00	10.00*	28.48**	19.24*
10.	RK8803 x Mathura Rai	-13.16**	13.22**	0.03**	-17.86**	-3.31	-10.58*
11.	RK8901 x Mathura Rai	-5.55	-5.51**	-5.53*	7.86	26.49**	17.17*
12.	RK8902 x Mathura Rai	-11.59**	-11.55**	-11.57**	-6.43	9.27	1.42
13.	RK8903 x Mathura Rai	-14.17**	-14.19**	-14.18**	-3.57	13.24*	4.83
14.	RL9001 x Mathura Rai	3.37**	3.31**	3.34**	-2.71**	-14.56**	-8.63**
15.	RK9002 x Mathura Rai	-1.27**	-1.26	-1.26*	6.42	25.16**	15.79*
16.	RK918506 x Mathura Rai	0.03	0.07	0.05	19.28**	39.73**	29.50**
17.	RK911296 x Mathura Rai	-13.95**	13.97**	0.01**	3.57	21.19**	12.34*
18.	RK9 x Mathura Rai	7.23**	7.27**	7.25**	-10.00*	5.96	-2.02
19.	RK14 x Mathura Rai	4.47**	4.47**	4.47**	-11.43*	39.73	14.15
20.	KRV 47 x Mathura Rai	4.61**	4.63**	0.01**	-20.00**	-5.96	-12.98**
21.	RK8601 x Laha 101	0.15	0.22	0.03	2.14	37.09**	-19.61*
22.	RK8602 x Laha 101	-4.13**	-4.12**	-4.12**	-43.57**	-33.77**	-38.67**
23	RK8604 x Laha 101	1.46	1.45	0.00	-35.00**	-23.18**	-29.09**
24	RK8605 x Laha 101	-2.06	2.07	0.01	-17.14**	-3.31	-10.22*
25	RK8608 x Laha 101	-13.35**	-13.38**	-13.36**	-12.86**	2.65	-5.10*
26.	RK8701 x Laha 101	0.56	0.57	0.56	-4.28	12.58*	-4.15
27.	RK8702 x Laha 101	-14.32**	14.33**	0.00**	-17.86**	3.31	-7.27*
28.	RK8801 x Laha 101	-5.14**	-4.85**	-4.99**	-10.71*	4.63	3.04
29.	RK8802 x Laha 101	-10.79**	10.80**	0.00**	-25.50**	-11.92*	18.71*
30.	RK8803 x Laha 101	5.09**	5.07**	0.01**	-24.28**	-10.59*	17.43*
31.	RK8901 x Laha 101	7.28**	7.27**	0.01**	29.28**	40.39**	29.83**
32.	RK8902 x Laha 101	-9.89**	10.01**	0.06**	29.28**	51.65**	40.46**
33.	RK8903 x Laha 101	4.27**	4.25**	4.26**	17.86**	38.41**	20.13**
34.	RL9001 x Laha 101	9.25**	9.26	9.25*	18.57**	-4.63	6.97*
35.	RK9002 x Laha 101	-1.38	-1.32	1.35	-17.24**	-2.65	-9.94*
36.	RK918506 x Laha 101	2.70*	2.69*	2.69*	-27.14*	-13.90**	-20.52**
37.	RK911296 x Laha 101	-6.72**	-4.72**	-5.72**	8.57	27.81**	18.19*
38.	RK9 x Laha 101	-1.24	-1.19	-1.21	-4.28	11.92*	3.82
39.	RK14 x Laha 101	-15.29**	-15.29**	-15.29**	2.86	20.53**	11.69*
40.	KRV 47 x Laha 101	-7.54**	-7.58**	-7.56**	0.71	17.88**	9.29*
41.	RK8601 xVaibhav	-1.61	-1.63	-1.62	7.86	17.22**	12.54*
42.	RK8602 xVaibhav	-8.24**	-8.15**	-8.19**	-4.28	11.92*	3.82
43.	RK8604 xVaibhav	-11.69**	-11.77**	11.73**	-9.28	5.96	-1.66
44	RK8605 xVaibhav	6.04**	6.02**	6.03**	-10.79*	4.63	-3.08
45.	RK8608 xVaibhav	-1.77	-1.85	-1.81	-16.46**	-1.99	-9.22*
46.	RK8701 xVaibhav	-2.10	-2.14	-2.12	-18.57**	-3.97	-11.27*
47.	RK8702 xVaibhav	-11.25**	-11.24**	11.24**	-60.43**	-1.32	-8.87*
48.	RK8801 xVaibhav	-14.62**	-14.63**	-14.62**	10.00*	-5.29	2.35
49.	RK8802 xVaibhav	-6.86**	-7.20**	-7.03**	-22.86**	-9.93	-16.38*
50.	RK8803 xVaibhav	-16.33**	-15.36**	- 15.84**	-24.28**	-10.59*	-17.43*
51.	RK8901 xVaibhav	-3.68**	-3.68**	-3.68**	-25.71**	-13.29*	-19.50*
52.	RK8902 xVaibhav	-16.84**	-16.84**	-16.84**	-27.14**	-14.56	-20.85
53.	RK8903 xVaibhav	-3.37**	-3.94**	-3.65**	-16.43**	-1.32	-8.87
54.	RL9001 xVaibhav	-7.46**	-7.42**	-7.44**	5.00	11.92*	8.46
55.	RK9002 xVaibhav	-13.08**	-13.16**	13.12**	-5.07**	-41.72**	-23.39**
56.	RK918506 xVaibhav	-7.79**	-7.80**	-7.79**	-27.14**	-13.91**	-20.52**
57.	RK911296 xVaibhav	-1.54	-1.54	-1.54	3.57	13.24**	8.40
58.	RK9 x Vaibhav	3.52**	3.53**	3.52**	5.71	23.84**	14.77*
59.	RK14 xVaibhav	6.37**	6.39**	6.38**	-24.28**	11.26*	-6.51*
60.	KRV 47 xVaibhav	-0.79	0.81	0.01	-52.86**	-44.37**	-48.61**
	SE [Diff. ≡(+)]	1.07	0.54	0.60	0.69	0.79	0.05

Table 8a: Contd.

		Economic heterosis over best parent					
		Yield per plant			Oil content		
S.N.	Crosses	E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	1.99	142.27**	170.63**	29.91**	18.33**	24.12**
2.	RK8602 x Mathura Rai	157.41**	154.28**	155.84**	31.09**	19.06**	25.07**
3.	RK8604 x Mathura Rai	35.64**	32.31**	33.97**	30.97**	18.98**	24.97**
4.	RK8605 x Mathura Rai	39.59**	39.17**	39.38**	20.90**	12.82**	16.86**
5.	RK8608 x Mathura Rai	204.39**	197.26**	201.09**	23.14**	14.18**	18.66**
6.	RK8701 x Mathura Rai	18.80**	18.55	18.67*	22.23**	13.64**	17.93**
7.	RK8702 x Mathura Rai	25.72**	23.71**	24.71**	22.49**	13.79**	18.14**
8.	RK8801 x Mathura Rai	163.35**	159.43**	161.39**	16.78**	10.31**	13.54**
9.	RK8802 x Mathura Rai	51.47**	49.48**	50.47**	14.54**	8.91**	11.72**
10.	RK8803 x Mathura Rai	77.22**	75.26**	76.24**	25.25**	15.49**	20.37**
11.	RK8901 x Mathura Rai	37.60**	35.72**	36.66**	13.36**	6.97	10.16*
12.	RK8902 x Mathura Rai	39.59**	39.17**	39.38**	27.79**	17.01**	22.40**
13.	RK8903 x Mathura Rai	36.62**	34.02**	35.32**	20.37**	12.48**	16.42**
14.	RL9001 x Mathura Rai	112.86**	37.47**	75.16**	7.92**	4.88	6.40*
15.	RK9002 x Mathura Rai	73.24**	70.10**	71.67**	14.19**	8.09**	11.14**
16.	RK918506 x Mathura Rai	77.26**	80.41**	78.83**	18.37**	11.27**	14.82**
17.	RK911296 x Maathura Rai	99.97**	95.87**	97.92**	14.39**	8.83**	11.61**
18.	RK9 x Mathura Rai	112.86**	10.96	61.91**	13.07**	8.02**	10.54**
19.	RK14 x Mathura Rai	136.62**	133.66**	135.14**	17.19**	10.53**	13.86**
20.	KRV 47 x Mathura Rai	139.59**	135.41**	137.50**	15.18**	9.34**	12.26**
21.	RK8601 x Laha 101	150.32**	147.42**	148.87**	29.88**	18.32**	24.10**
22.	RK8601 x Laha 101	67.30**	64.95**	66.12**	16.13**	7.32*	11.72*
23	RK8604 x Laha 101	56.43**	54.64**	55.53**	8.44**	5.19	6.81*
24	RK8605 x Laha 101	142.56**	138.81**	140.68**	16.13**	9.88**	13.00**
25	RK8608 x Laha 101	39.59**	37.47**	38.53**	-0.97	-4.45	-2.71
26.	RK8701 x Laha 101	64.33**	61.49**	62.91**	15.87**	9.72**	8.29**
27.	RK8702 x Laha 101	34.33**	32.32**	33.32**	24.72**	15.15**	19.93**
28.	RK8801 x Laha 101	-16.84	-19.23	-18.03	11.36**	6.97*	9.16*
29.	RK8802 x Laha 101	80.19**	78.71**	79.45**	18.63**	11.19**	14.91**
30.	RK8803 x Laha 101	27.71**	76.96**	52.33**	18.89**	11.58**	15.24
31.	RK8901 x Laha 101	94.45**	92.42**	93.43**	17.57**	10.77**	14.17**
32.	RK8901 x Laha 101	28.69**	27.16**	27.92**	22.61**	13.87**	18.24**
33.	RK8903 x Laha 101	49.48**	46.03**	47.75**	16.93**	10.38**	13.65**
34.	RL9001 x Laha 101	52.45**	49.48**	50.96**	25.40**	15.57**	20.48*
35.	RK9002 x Laha 101	22.75**	20.26*	21.50*	8.04**	4.96	6.50*
36.	RK918506 x Laha 101	20.79**	20.26*	20.52**	35.33**	21.66**	28.49**
37.	RK911296 x Laha 101	23.76**	-26.13**	-1.18**	18.69**	16.85**	17.77**
38.	RK9 x Laha 101	34.63**	32.31**	33.47**	11.48**	7.44*	9.46*
39.	RK14 x Laha 101	85.12**	82.11**	83.61**	32.03**	6.70*	19.36*
40.	KRV 47 x Laha 101	243.54**	231.59**	237.56**	8.57**	5.27	6.92*
41.	RK8601 xVaibhav	112.86**	10.96**	61.91**	20.37**	12.47**	16.42**
42.	RK8602 xVaibhav	65.34**	63.25**	64.29**	32.29**	19.76**	26.02**
43.	RK8604 xVaibhav	175.23**	169.74**	172.48**	25.79**	15.81**	20.80**
44	RK8605 xVaibhav	36.62**	34.02**	35.32**	10.95**	6.74*	8.84*
45.	RK8608 xVaibhav	130.68**	126.80**	128.74**	1.03	3.89	2.46
46.	RK8701 xVaibhav	55.42**	52.94**	54.18**	18.52**	11.35**	14.93**
47.	RK8702 xVaibhav	62.28**	50.79**	56.53**	14.54**	8.91**	11.72**
48.	RK8801 xVaibhav	34.63**	32.32**	33.47**	-3.62	-2.17	-2.89
49.	RK8802 xVaibhav	41.37**	39.17**	40.27**	-0.18	0.08	-0.05
50.	RK8803 xVaibhav	39.58**	35.72**	37.65**	25.93**	15.88**	20.90**
51.	RK8901 xVaibhav	19.78**	18.55*	19.16*	01.68	1.05	1.36
52.	RK8902 xVaibhav	22.75**	20.26*	21.50*	16.13**	9.88**	13.00**
53.	RK8903 xVaibhav	38.61**	37.47**	38.04**	16.92**	10.38**	-13.65**
54.	RL9001 xVaibhav	31.66**	30.57**	31.11**	-1.09	-0.66	-0.87
55.	RK9002 xVaibhav	43.54**	40.87**	42.20**	-0.56	-0.35	-0.45
56.	RK918506 xVaibhav	2.97	1.39	2.18	-4.42	-2.71	-3.56
57.	RK911296 xVaibhav	36.62**	35.72**	36.17**	4.59	2.83	3.71
58.	RK9 x Vaibhav	15.83*	15.10*	15.46*	24.87**	15.26**	20.06**
59.	RK14 xVaibhav	1.96	1.39	1.67	-0.03	0.00	-0.01
60.	KRV 47 xVaibhav`	37.60**	35.72**	36.66**	8.98**	5.50	7.24**
	SE [Diff.≅(±)]	2.25	2.42	1.65	1.04	0.82	0.66

Table 8a: Contd.

		Economic heterosis over best parent		
		Erucic acid		
S.N.	Crosses	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	-1.88	0.28	-0.80
2.	RK8602 x Mathura Rai	-1.28	0.90	-0.19
3.	RK8604 x Mathura Rai	-0.07	0.28	0.11
4.	RK8605 x Mathura Rai	-0.07	0.90	-0.42
5.	RK8608 x Mathura Rai	-0.67	0.90	-0.12
6.	RK8701 x Mathura Rai	-0.67	0.90	0.12
7.	RK8702 x Mathura Rai	-1.88	-1.10	-1.49
8.	RK8801 x Mathura Rai	-1.28	-1.10	-1.19
9.	RK8802 x Mathura Rai	-1.33	-2.49*	-1.91
10.	RK8803 x Mathura Rai	-1.33	-2.49*	-1.91
11.	RK8901 x Mathura Rai	-4.58*	-1.10	-2.84*
12.	RK8902 x Mathura Rai	-0.67	-0.44	-0.56
13.	RK8903 x Mathura Rai	-0.67	0.90	0.79
14.	RL9001 x Mathura Rai	-1.88	-0.48	-1.18
15.	RK9002 x Mathura Rai	-1.88	-2.49*	-2.19
16.	RK918506 x Mathura. Rai	-1.88	-1.10	-1.49
17.	RK911296 x Mathura Rai	-1.88	0.28	0.80
18.	RK9 x Mathura Rai	-2.48*	0.28	-1.10
19.	RK14 x Mathura Rai	-2.48*	0.90	-0.79
20.	KRV 47 x Mathura Rai	-0.67	1.52	0.43
21.	RK8601 x Laha 101	-1.28	-0.48	-0.88
22.	RK8602 x Laha 101	-1.28	-4.50**	-2.89*
23	RK8604 x Laha 101	-1.28	-3.87**	-2.58*
24	RK8605 x Laha 101	-1.80	-1.86	-1.83
25	RK8608 x Laha 101	-2.01	-0.48	-1.25
26.	RK8701 x Laha 101	-1.88	-1.52	-1.70
27.	RK8702 x Laha 101	-1.88	1.52	-1.70
28.	RK8801 x Laha 101	-1.28	-1.10	-1.19
29.	RK8802 x Laha 101	-1.28	-2.49*	-1.89
30.	RK8803 x Laha 101	-1.28	-1.10	-1.19
31.	RK8901 x Laha 101	-1.28	-3.11	-2.19
32.	RK8902 x Laha 101	-2.48*	-3.87**	-3.18**
33.	RK8903 x Laha 101	-2.48*	-1.86	-2.17
34.	RL9001 x Laha 101	-1.88	0.14	-0.87
35.	RK9002 x Laha 101	-1.88	-0.48	-1.18
36.	RK918506 x Laha 101	-1.28	-2.49	-1.89
37.	RK911296 x Laha 101	-1.28	-5.26**	-3.27**
38.	RK9 x Laha 101	-1.88	-3.87**	-2.88**
39.	RK14 x Laha 101	-2.48*	-0.48	-1.48
40.	KRV 47 x Laha 101	-2.48*	-2.49*	-2.49*
41.	RK8601 xVaibhav	-2.48*	-2.49	-2.49*
42.	RK8602 xVaibhav	-1.88	-1.10	-1.14
43.	RK8604 xVaibhav	-1.88	-2.49*	-2.19
44	RK8605 xVaibhav	-1.88	-2.49*	-2.19
45	RK8608 xVaibhav	-1.88	-1.10	-1.14
46.	RK8701 xVaibhav	-1.88	-1.86	-1.87
47.	RK8702 xVaibhav	-2.48*	-1.86	-2.17
48.	RK8801 xVaibhav	-1.88	-0.48	-1.18
49.	RK8802 xVaibhav	-1.28	-4.50**	-2.89*
50.	RK8803 xVaibhav	-1.88	0.14	-0.87
51.	RK8901 xVaibhav	-1.28	-1.86	-1.57
52.	RK8902 xVaibhav	-1.88	-1.86	-1.87
53.	RK8903 xVaibhav	-1.28	-1.24	-1.26
54.	RL9001 xVaibhav	-1.28	-3.25**	-2.26
55.	RK9002 xVaibhav	-1.28	-5.26**	-3.27**
56.	RK918506 xVaibhav	-1.28	-0.06	-0.67
57.	RK911296 xVaibhav	-1.88	-3.25**	-2.57*
58.	RK9 x Vaibhav	-1.88	-1.24	-1.56
59.	RK14 xVaibhav	-1.88	-3.25**	-2.57*
60.	KRV 47 xVaibhav	-1.88	0.14	-1.01
	SE [Diff. ≅ (+)]	0.68	0.55	0.77

* Significant at p=0.05   ** Significant at p=0.01

Table 8b: Estimates of inbreeding depression in two environments [normal sown (E_1)and late sown (E_2)] alongwith pooled values for 13 characters in 60 F_1 s of Indian mustard

		Inbreeding depression over best parent					
		Days to flowering			Days to reproductive phase		
S.N.	Crosses	E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	16.40**	13.63**	15.02**	-3.84	11.27*	3.72
2.	RK8602 x Mathura Rai	-8.26**	-7.02**	-7.64**	0.36	13.07**	6.72
3.	RK8604 x Mathura Rai	2.97	1.05	2.01	2.14	15.35**	8.75
4.	RK8605 x Mathura Rai	6.85*	-7.36**	0.26	-3.35	10.96**	3.81
5.	RK8608 x Mathura Rai	-5.94	-4.19	-5.07	5.98	9.14*	7.56
6.	RK8701 x Mathura Rai	4.69	0.00	2.35	14.52**	3.41	8.97
7.	RK8702 x Mathura Rai	7.85*	4.24	6.05	13.61**	3.38	8.50
8.	RK8801 x Mathura Rai	-21.77**	-15.79**	-18.78**	-2.72	12.27**	4.78
9.	RK8802 x Mathura Rai	-13.44**	-2.07	-7.76	5.27	18.36**	11.82*
10.	RK8803 x Mathura Rai	4.68	3.06	3.88	-5.57	9.67*	2.05
11.	RK8901 x Mathura Rai	-15.46**	-13.19**	-14.33**	0.80`	14.01**	7.41
12.	RK8902 x Mathura Rai	1.92	-4.19	-1.14	-1.49	9.63*	4.07
13.	RK8903 x Mathura Rai	-3.69	2.03	-0.83	-8.53	4.24	2.15
14.	RL9001 x Mathura Rai	2.45	2.75	2.60	0.35	16.52**	8.44
15.	RK9002 x Mathura Rai	-12.00**	-8.52**	-10.26**	-1.08	11.95**	5.94
16.	RK918506 x Mathura Rai	10.62**	7.75**	9.18**	-8.84**	23.72**	7.44
17.	RK911296 x Mathura Rai	0.99	-1.04	-0.03	9.38**`	21.46**	15.42**
18.	RK9 x Mathura Rai	4.39	-4.86	-0.24	3.36	17.33**	10.35
19.	RK14 x Mathura Rai	-4.57	3.00	-0.79	-0.37	13.35**	6.49
20.	KRV 47 x Mathura Rai	13.06**	-10.19**	1.44	0.00	13.33**	6.67
21.	RK8601 x Laha 101	-8.41*	7.06**	-0.68	-7.47	7.77	0.15
22.	RK8602 x Laha 101	2.94	-2.08	0.43	-7.42	7.30	-0.06
23	RK8604 x Laha 101	-0.85	-0.94	-0.90	-0.39	13.68**	6.82
24	RK8605 x Laha 101	-8.14*	-4.29	-6.22	12.50**	23.61**	18.05*
25	RK8608 x Laha 101	-1.90	-2.16	-2.03	2.88	15.25**`	9.07
26.	RK8701 x Laha 101	3.46	2.86	3.16	8.48*	20.08**	14.28
27.	RK8702 x Laha 101	3.56	2.94	3.25	7.36	19.46**	13.41*
28.	RK8801 x Laha 101	3.46	5.71**	4.58*	11.95**	16.87**	14.41*
29.	RK8802 x Laha 101	-9.33**	-9.18**	-9.26**	-4.53	10.13*	2.80
30.	RK8803 x Laha 101	-1.91	5.71*	1.90	-2.31	18.96**	8.33
31.	RK8901 x Laha 101	2.54	11.00**	6.77	-3.71	10.51*	3.40
32.	RK8902 x Laha 101	-12.62**	0.00	-6.31	14.00**	15.19**	0.60
33.	RK8903 x Laha 101	7.12*	13.39**	10.26*	-11.20**	21.21**	5.01**
34.	RL9001 x Laha 101	17.67**	25.39**	21.53**	2.55	15.24**	8.90
35.	RK9002 x Laha 101	-9.98**	0.93	-4.53	-9.30*	6.54	-1.38
36.	RK918506 x Laha 101	3.65	10.90**	7.28	6.21	18.37**	12.29
37.	RK911296 x Laha 101	-3.53	6.21**	1.34	9.18*	20.55**	14.87*
38.	RK9 x Laha 101	0.00	25.23**	12.62	3.28	15.77**	9.53*
39.	RK14 x Laha 101	-13.92**	25.98**	6.03**	0.74	14.15**	7.45
40.	KRV 47 x Laha 101	-13.21**	-0.96	-7.08	0.71	11.21**	5.96
41.	RK8601 xVaibhav	6.94*	13.90**	10.42*	-1.38	12.18**	5.40
42.	RK8602 xVaibhav	11.85**	18.40**	15.13**	6.16	14.29**	10.23*
43.	RK8604 xVaibhav	0.00	6.76**	3.38	3.08	16.82**	9.95*
44	RK8605 xVaibhav	-6.02*	6.05**	0.02	2.58	15.39**	8.99
45.	RK8608 xVaibhav	0.94	20.00**	10.47	-5.62	9.59*	1.99
46.	RK8701 xVaibhav	16.26**	21.95**	19.11	2.52	15.79**	9.16
47.	RK8702 xVaibhav	-14.70**	-3.91	-9.31	-3.46	5.61	1.08
48.	RK8801 xVaibhav	6.85*	14-54**	10.70*	-9.52*	6.24	-1.64
49.	RK8802 xVaibhav	5.40	12.62**	9.01	-7.51**	7.80	0.15
50.	RK8803 xVaibhav	16.79**	26.39**	21.59**	0.35	13.15**	6.40
51.	RK8901 xVaibhav	13.69**	13.69**	13.69**	5.53	17.60**	11.57*
52.	RK8902 xVaibhav	8.11*	7.28**	7.70**	2.91	15.31**	9.11
53.	RK8903 xVaibhav	0.00	0.00	0.00	7.55	18.67**	13.11**
54.	RL9001 xVaibhav	-4.70	-4.78*	-4.74	4.51	16.81**	10.66*
55.	RK9002 xVaibhav	0.92	0.92	0.92	0.00	12.98**	6.47
56.	RK918506 xVaibhav	0.00	0.00	0.00	-0.35	12.78**	6.22
57.	RK911296 xVaibhav	19.36**	19.36**	19.36**	0.00	14.03**	7.02
58.	RK9 x Vaibhav	6.76*	6.76**	6.76**	-5.95	9.61*	1.83
59.	RK14 xVaibhav	-28.41**	-20.79**	-24.60**	0.00	13.93**	6.97
60.	KRV 47 xVaibhav	-10.02**	-10.02**	-10.02**	4.24	16.41**	10.33*
	SE [Diff. ≅(+)]	1.09	0.79	2.46	3.73	3.20	3.71

Table 8b: Contd.

S.N.	Crosses	Inbreeding depression over best parent					
		Number of primary branches			Number of Secondary branches		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	37.50**	14.99*	26.24**	42.23**	84.54**	63.38**
2.	RK8602 x Mathura Rai	20.82	14.99	17.93	49.44**	84.54**	66.99**
3.	RK8604 x Mathura Rai	50.00**	43.74**	46.87**	38.68**	57.67**	48.17**
4.	RK8605 x Mathura Rai	4.50**	5.34	4.92	3.24	30.68	16.96
5.	RK8608 x Mathura Rai	48.59	67.76**	58.17	54.64**	126.87**	90.75**
6.	RK8701 x Mathura Rai	21.77	10.27	16.02	34.36**	30.68**	32.52**
7.	RK8702 x Mathura Rai	21.01	-9.03	5.99	3.72	15.34	9.52
8.	RK8801 x Mathura Rai	48.40**	48.46**	48.58**	37.19**	65.28**	51.23**
9.	RK8802 x Mathura Rai	36.36**	58.11	47.23	49.19**	30.68**	39.93**
10.	RK8803 x Mathura Rai	4.21	0.62	2.41	26.53**	38.41**	32.47**
11.	RK8901 x Mathura Rai	7.44	29.36	18.40	5.91**	42.21**	24.06
12.	RK8902 x Mathura Rai	-22.16	13.74	-17.96	38.02**	49.94**	43.98**
13.	RK8903 x Mathura Rai	30.00	43.74*	36.87**	24.32**	57.67**	40.99**
14.	RL9001 x Mathura Rai	16.02	48.44	32.25	-20.62**	30.68**	5.03**
15.	RK9002 x Mathura Rai	40.00**	28.13	34.06	-42.61	15.34**	-13.63
16.	RK918506 x Mathura Rai	12.50	14.99	13.74	-12.48	15.34	1.43
17.	RK911296 x Mathura Rai	27.28*	5.34	16.31	-1.74	19.15	8.70
18.	RK9 x Mathura Rai	22.28	29.36	25.99	41.94**	92.27**	67.10**
19.	RK14 x Mathura Rai	4.50	5.34	18.76	29.50**	65.28**	47.39**
20.	KRV 47 x Mathura Rai	31.79*	5.34*	13.74	41.32**	57.67**	49.49**
21.	RK8601 x Laha 101	12.50	14.99	13.74	-3.00	38.41	17.70
22.	RK8602 x Laha 101	18.55	29.36	23.95	-22.24**	30.68**	4.22**
23	RK8604 x Laha 101	0.00	-1.08	-0.54	-13.05	-3.92	-8.48
24	RK8605 x Laha 101	0.00	-13.76	-6.88	-33.33**	-3.92**	-18.62**
25	RK8608 x Laha 101	45.70**	67.76**	56.76**	36.11**	126.87**	81.49**
26.	RK8701 x Laha 101	26.60	-28.13	-0.76	3.69	19.14	11.36
27.	RK8702 x Laha 101	34.55**	10.26*	22.40**	21.74**	42.21**	31.97**
28.	RK8801 x Laha 101	32.34**	47.00*	40.09**	49.13**	142.21**	45.67**
29.	RK8802 x Laha 101	23.80	0.62	11.99	5.77	7.61	6.69
30.	RK8803 x Laha 101	-31.33	-23.41	-27.37	-27.91*	7.73**	10.09**
31.	RK8901 x Laha 101	-14.28	0.62	-6.83	28.00**	57.67**	42.83**
32.	RK8902 x Laha 101	44.44**	8.82**	26.62**	46.75**	65.28	56.01
33.	RK8903 x Laha 101	4.71	0.62	2.66	14.05	19.14	16.59
34.	RL9001 x Laha 101	12.50	14.99	13.74	1.82	15.34	8.65
35.	RK9002 x Laha 101	14.78	29.36	22.07	-4.76	30.68	12.96
36.	RK918506 x Laha 101	-33.33*	-13.76	-23.54	-28.55**	15.34**	-6.60**
37.	RK911296 x Laha 101	-22.17	-13.76	-17.96	1.50	38.41	19.95
38.	RK9 x Laha 101	40.00**	43.74**	41.87**	40.46**	73.01**	56.73**
39.	RK14 x Laha 101	51.55**	58.11**	54.83**	57.14**	99.88**	78.01**
40.	KRV 47 x Laha 101	42.45**	39.01*	40.73**	18.68**	57.67**	38.17**
41.	RK8601 xVaibhav	59.45**	77.21**	68.33**	62.83**	138.41**	100.62**
42.	RK8602 xVaibhav	36.01**	19.71*	27.86**	25.94**	15.34*	20.64**
43.	RK8604 xVaibhav	30.00**	43.74*	36.90**	52.58**	99.88**	76.23**
44	RK8605 xVaibhav	44.44**	29.36**	36.90**	34.29**	46.14**	41.71**
45.	RK8608 xVaibhav	46.70**	43.74**	45.22**	54.88**	73.01**	36.88**
46.	RK8701 xVaibhav	43.30**	43.74**	43.52**	30.50**	33.07**	26.78**
47.	RK8702 xVaibhav	54.33**	67.76**	61.04**	36.65**	26.87**	31.76**
48.	RK8801 xVaibhav	37.00**	29.36*	33.18**	33.86**	26.87**	30.36**
49.	RK8802 xVaibhav	22.22*	29.98	26.10	37.19**	65.28**	51.23**
50.	RK8803 xVaibhav	51.89**	77.21**	64.55**	12.94	15.34	14.14
51.	RK8901 xVaibhav	-27.83*	19.71	-4.06	0.00	-3.92	-1.96
52.	RK8902 xVaibhav	0.00	43.74	21.87	41.20**	38.41**	39.80**
53.	RK8903 xVaibhav	21.01	29.36**	25.18	-2.25	-7.73	-4.99
54.	RL9001 xVaibhav	19.00	43.74**	31.37	-14.63	-11.53	-6.58
55.	RK9002 xVaibhav	0.00	43.74	21.87	-27.27*	-3.92*	-15.59*
56.	RK918506 xVaibhav	50.10**	67.76**	58.93**	5.66	11.53	8.59
57.	RK911296 xVaibhav	33.30**	29.36*	31.33**	14.99	34.60**	24.79
58.	RK9 x Vaibhav	23.07*	29.36*	26.21*	12.25	3.81	8.28
59.	RK14 xVaibhav	46.70**	43.74**	45.22**	42.31**	61.48**	51.89**
60.	KRV 47 xVaibhav	41.92**	48.46**	45.19**	27.57**	19.14*	23.35**
	SE [Diff. ≅(±)]	0.84	0.79	0.58	1.37	0.78	0.79

Table 8b: Contd.

		Inbreeding depression over best parent					
		Height of plant			Length of main fruiting branch		
S.N.	Crosses	E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	-6.26	-5.91	-6.09	3.57	-8.67**	2.55
2.	RK8602 x Mathura Rai	-10.80	-30.52**	20.66*	37.55**	19.37**	28.46**
3.	RK8604 x Mathura Rai	-13.23*	-12.00*	-12.62	14.35**	-20.39**	-3.02
4.	RK8605 x Mathura Rai	-3.31	-9.02*	-6.17	23.48**	11.48**	17.48**
5.	RK8608 x Mathura Rai	-7.28*	-20.48**	-13.88*	16.77**	-48.24**	15.73**
6.	RK8701 x Mathura Rai	-4.64	-23.62**	-14.13*	25.99**	10.07**	18.03**
7.	RK8702 x Mathura Rai	-5.94	-6.32	-6.13	26.45**	11.45**	18.95**
8.	RK8801 x Mathura Rai	-4.53	-3.89	-4.21	23.11**	7.09*	15.10*
9.	RK8802 x Mathura Rai	-0.40	-5.92	-3.16	15.82**	1.63	8.73
10.	RK8803 x Mathura Rai	-7.32	-12.59**	-9.96*	-3.88	-14.80**	-9.34
11.	RK8901 x Mathura Rai	4.43	13.79**	9.11	-24.69**	10.15**	-7.27**
12.	RK8902 x Mathura Rai	-12.96*	-8.24	-10.60	-1.03	-13.16**	-7.09
13.	RK8903 x Mathura Rai	-4.30	-22.96**	13.63**	27.99**	14.29**	21.14**
14.	RL9001 x Mathura Rai	-0.81	-5.34	2.27	11.31**	19.22**	15.27**
15.	RK9002 x Mathura Rai	0.00	-4.65	-2.33	16.16**	2.27	9.22
16.	RK918506 x Mathura Rai	-0.79	-7.19	-3.20	7.49**	-5.49	1.01
17.	RK911296 x Mathura Rai	8.15	-6.11	1.02	19.49**	13.03**	16.26**
18.	RK9 x Mathura Rai	-6.83	14.08**	3.63	0.42	-9.84	-4.71
19.	RK14 x Mathura Rai	5.18	-2.68	1.25	33.03**	15.07**	24.05**
20.	KRV 47 x Mathura Rai	16.29**	3.55	9.92	9.16**	2.13	5.65
21.	RK8601 x Laha 101	16.10**	-6.52	-11.31	1.46	32.77**	17.12
22.	RK8602 x Laha 101	0.61	-4.33	1.86	19.16**	9.84**	14.50**
23	RK8604 x Laha 101	-8.61	-5.96	-7.29	21.73**	5.04	13.39
24	RK8605 x Laha 101	-3.88	-2.41	-3.15	29.45**	18.19**	23.82**
25	RK8608 x Laha 101	-4.61	11.97**	2.68	18.59**	11.65**	15.12**
26.	RK8701 x Laha 101	-2.24	5.27	1.52	28.69**	12.96**	20.82**
27.	RK8702 x Laha 101	-6.81	-9.50*	-8.15*	11.29**	16.36**	13.83**
28.	RK8801 x Laha 101	-2.02	15.81	6.90	11.15**	0.93	6.04
29.	RK8802 x Laha 101	7.38*	-6.97	0.21	52.06**	43.17**	47.62**
30.	RK8803 x Laha 101	-0.20	6.49	1.80	29.52**	1.56	15.54
31.	RK8901 x Laha 101	9.43*	-9.07*	0.18	-8.26**	18.71**	5.23
32.	RK8902 x Laha 101	-7.43	2.10	-2.67	1.65	10.79**	6.22
33.	RK8903 x Laha 101	-2.07	-18.84**	-10.46	1.79	-8.59**	-3.40
34.	RL9001 x Laha 101	-7.11	-22.53**	-14.82	-1.56	-13.27**	-7.42
35.	RK9002 x Laha 101	14.63**	-9.13**	2.75	39.92**	17.65**	28.79**
36.	RK918506 x Laha 101	-18.67**	-36.36**	-27.51**	-15.52**	-25.24**	-20.38**
37.	RK911296 x Laha 101	-13.59**	-19.04**	-16.32**	13.15**	-6.18	3.49
38.	RK9 x Laha 101	0.00	9.75**	4.88	-0.49	-12.82**	-6.66
39.	RK14 x Laha 101	-25.00**	-22.63**	-23.82	24.77**	9.30**	17.04**
40.	KRV 47 x Laha 101	-3.49	-3.06	-3.28	22.51**	7.68*	15.09
41.	RK8601 xVaibhav	13.52**	12.50**	13.01**	33.65**	15.43**	24.54**
42.	RK8602 xVaibhav	-28.39**	-25.85	-27.12*	0.59	-12.64**	-6.03
43.	RK8604 xVaibhav	-11.21*	-32.97**	22.09*	52.36**	26.87**	39.61**
44	RK8605 xVaibhav	0.39	-9.91**	-4.76	15.23**	-23.86**	4.31
45.	RK8608 xVaibhav	0.20	20.95**	10.38	4.54	-7.76*	-1.61
46.	RK8701 xVaibhav	0.79	-13.68**	-6.45	22.94**	18.71**	20.68
47.	RK8702 xVaibhav	16.09**	6.34	11.22*	40.49**	39.17**	39.83
48.	RK8801 xVaibhav	6.95	30.36**	18.66	13.17**	-1.74	5.72
49.	RK8802 xVaibhav	0.00	21.89**	10.95	12.21**	-4.02	4.09
50.	RK8803 xVaibhav	17.93**	-16.35**	0.79	41.95**	23.47**	32.71**
51.	RK8901 xVaibhav	4.52	2.44	3.48	-7.14**	-23.68**	-15.41**
52.	RK8902 xVaibhav	-0.41	-11.05**	-5.73	49.78**	28.92**	39.35**
53.	RK8903 xVaibhav	-4.75	-9.73*	-7.24*	27.63**	10.34**	18.99**
54.	RL9001 xVaibhav	-2.44	8.40**	2.98	1.49	-9.41**	-3.96
55.	RK9002 xVaibhav	14.11**	32.35**	23.23*	11.90**	-15.02**	-1.56
56.	RK918506 xVaibhav	-1.41	25.14**	11.87	26.52**	-34.88**	-4.18
57.	RK911296 xVaibhav	-3.69	1.87	0.91	20.33**	10.00**	15.17*
58.	RK9 x Vaibhav	-9.33	8.19	-0.57	28.30**	9.92**	19.11**
59.	RK14 xVaibhav	0.60	29.98**	15.29*	57.47**	35.07**	46.27**
60.	KRV 47 xVaibhav	-1.18	5.92	2.37	27.56**	10.56**	19.06
	SE [Diff. ≅(+)]	7.87	5.44	7.05	1.59	1.38	3.39

Table 8b Contd.

		Inbreeding depression over best parent					
		No. of siliquae on main fruiting branch			Days to maturity		
S.N.	Crosses	E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	-6.79*	8.89	1.05	3.41	7.43**	5.42
2.	RK8602 x Mathura Rai	2.49	8.89	5.69	-5.89**	2.17	-1.86
3.	RK8604 x Mathura Rai	1.39	-3.79	-1.20	2.88	6.52**	4.70
4.	RK8605 x Mathura Rai	10.69**	7.59*	9.14**	-0.54	4.76*	2.11
5.	RK8608 x Mathura Rai	-8.29*	6.34*	-0.97*	-5.97**	9.02**	1.53
6.	RK8701 x Mathura Rai	-18.19**	-18.98*	-18.58**	-8.76**	6.66**	-1.05
7.	RK8702 x Mathura Rai	-15.72**	-18.98	-17.35	-7.39**	7.85**	0.23
8.	RK8801 x Mathura Rai	-7.45	-17.69	-12.57	-8.11**	8.61**	0.25
9.	RK8802 x Mathura Rai	2.29	-12.64**	-5.17	0.01	7.60**	3.81
10.	RK8803 x Mathura Rai	-66.65**	-35.43**	-51.04**	-2.50	2.63	0.07
11.	RK8901 x Mathura Rai	-25.74**	-8.84	-17.29**	-4.88**	0.67	-2.11
12.	RK8902 x Mathura Rai	-10.50*	-16.44	-13.47	-0.54	2.29	0.88
13.	RK8903 x Mathura Rai	-8.73*	-16.44	-12.58	-5.19*	-1.28	-3.24
14.	RL9001 x Mathura Rai	31.00**	-2.50**	14.25**	0.72	7.02**	3.87*
15.	RK9002 x Mathura Rai	13.93**	6.34*	10.13**	-3.96	1.25	-1.36
16.	RK918506 x Mathura Rai	-2.19	-8.84	-5.51	-2.94	14.32**	5.69
17.	RK911296 x Mathura Rai	-7.84*	-7.59	-7.71	3.54	7.32**	5.43
18.	RK9 x Mathura Rai	15.98**	15.83**	15.90**	3.32	5.79**	4.56
19.	RK14 x Mathura Rai	28.82**	10.14**	19.48**	1.06	5.36**	3.21
20.	KRV 47 x Mathura Rai	3.55	-5.05	-0.75	-3.64	1.55	-1.05
21.	RK8601 x Laha 101	-19.83**	-15.19**	-17.51**	-2.94	2.83	-0.06
22.	RK8602 x Laha 101	-1.29	5.08	1.89	-6.19**	-6.31	-6.25**
23	RK8604 x Laha 101	-2.98	-7.59	-5.28	1.05	4.12*	2.59
24	RK8605 x Laha 101	15.22**	2.54**	8.88**	4.31*	8.29	6.30*
25	RK8608 x Laha 101	32.16**	34.18**	33.17**	1.57	5.62**	3.59
26.	RK8701 x Laha 101	-9.76*	-17.69	-13.72	7.05**	2.99	5.02*
27.	RK8702 x Laha 101	89.99**	-29.09**	30.45**	6.25**	6.51	6.38
28.	RK8801 x Laha 101	29.89**	10.14**	20.01**	-7.11**	9.06**	0.98
29.	RK8802 x Laha 101	4.79	11.39	8.09	-5.89**	-2.86	-4.23
30.	RK8803 x Laha 101	9.15*	-5.05**	2.05**	2.19	8.19**	5.19
31.	RK8901 x Laha 101	-63.86**	-12.64**	-38.25**	-1.81	2.77	0.48
32.	RK8902 x Laha 101	-18.99**	6.34**	-6.32**	-13.89**	3.54	-5.18
33.	RK8903 x Laha 101	17.14**	2.54**	9.84**	9.04**	2.70	5.87
34.	RL9001 x Laha 101	-59.34**	-17.69**	-38.51**	7.40**	9.33**	8.37**
35.	RK9002 x Laha 101	22.33**	44.32**	33.32**	-9.50**	-2.91	-6.21*
36.	RK918506 x Laha 101	8.06*	25.33*	16.69*	5.50**	9.52**	7.51
37.	RK911296 x Laha 101	-2.46	8.89	3.21	23.48**	-12.66**	5.41
38.	RK9 x Laha 101	8.88	13.93	11.40	25.98**	11.88**	18.93**
39.	RK14 x Laha 101	4.55*	32.92**	18.73**	16.56**	1.91	9.24*
40.	KRV 47 x Laha 101	-6.38	6.34	-0.02	16.01**	-0.09	8.05*
41.	RK8601 xVaibhav	43.63**	26.58**	35.10**	1.75**	5.39**	3.57**
42.	RK8602 xVaibhav	-5.28	-11.39	-8.33	26.09**	11.15**	18.62**
43.	RK8604 xVaibhav	32.09**	8.89**	20.49**	19.84**	5.60**	12.72**
44	RK8602 xVaibhav	18.57**	12.68**	15.62**	19.85**	4.61**	12.23**
45.	RK8608 xVaibhav	18.75**	7.59**	13.17**	20.15**	5.22**	12.69**
46.	RK8701 xVaibhav	5.40**	0.00**	2.70**	26.81**	10.36**	18.59**
47.	RK8702 xVaibhav	30.46**	17.73**	24.09**	10.78	-4.87*	2.96
48.	RK8801 xVaibhav	11.39**	6.34*	8.86*	15.99**	1.27	8.63
49.	RK8802 xVaibhav	-29.20**	-25.29**	-27.24**	17.19**	1.89	9.54
50.	RK8803 xVaibhav	12.73**	16.48*	14.60**	24.88**	10.29**	17.59**
51.	RK8901 xVaibhav	-33.34**	24.04**	-4.65**	25.90**	11.05**	18.48**
52.	RK8902 xVaibhav	1.46	-8.84	-3.69	22.39**	4.64*	13.52*
53.	RK8903 xVaibhav	24.46**	22.78**	22.62**	17.14**	1.23	9.17
54.	RL9001 xVaibhav	26.53**	41.77**	34.15**	21.17**	6.07**	13.62**
55.	RK9002 xVaibhav	39.69	30.36**	35.02	15.06**	4.35*	9.71*
56.	RK918506 xVaibhav	0.00	-10.10	-5.05	19.50**	4.32*	11.91*
57.	RK911296 xVaibhav	27.14**	10.14**	18.79**	24.18**	6.78**	15.48**
58.	RK9 x Vaibhav	7.09	24.04	15.56	18.10**	3.49	10.79
59.	RK14 xVaibhav	22.88**	3.79**	13.33**	15.70**	0.32	8.01
60.	KRV 47 xVaibhav	22.86**	-6.30**	8.28**	19.83**	4.94**	12.39**
	SE [Diff. ≡(+)]	1.75	1.34	1.10	2.62	2.11	5.79

Table 8b : Contd.

		Inbreeding depression over best parent					
		Relative water content			Leaf water potential		
S.N.	Crosses	E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	16.24**	3.87**	10.05**	23.84**	25.83**	24.83**
2.	RK8602 x Mathura Rai	-5.10*	-14.04*	9.57*	-32.43**	-6.62**	-19.52**
3.	RK8604 x Mathura Rai	-5.76**	-0.96**	3.36**	8.11	-7.28	0.41
4.	RK8605 x Mathura Rai	13.14**	-3.52**	4.81	-83.33**	-9.93**	-46.63**
5.	RK8608 x Mathura Rai	11.31**	-0.59**	5.36	-12.78**	11.92**	-0.43**
6.	RK8701 x Mathura Rai	8.72**	-24.78**	-8.03**	12.08**	24.50*	18.29**
7.	RK8702 x Mathura Rai	0.04	-5.51	-2.73	0.00	-4.63	-2.31
8.	RK8801 x Mathura Rai	3.79	-0.06*	1.86	-25.00**	0.66**	-12.17**
9.	RK8802 x Mathura Rai	-0.62*	1.54**	0.46**	-16.88**	28.48**	5.80**
10.	RK8803 x Mathura Rai	0.22**	13.22	6.72	1.74	-3.31	-0.78
11.	RK8901 x Mathura Rai	3.02	-5.51**	-1.24	11.26*	26.49*	18.87*
12.	RK8902 x Mathura Rai	-11.87**	-11.55**	-11.71**	-52.67**	9.27**	-21.70**
13.	RK8903 x Mathura Rai	-19.83**	-14.19**	-17.01**	22.96**	13.24**	18.10**
14.	RL9001 x Mathura Rai	5.58**	3.31**	4.44**	-27.45**	-14.56**	-21.00**
15.	RK9002 x Mathura Rai	0.64**	-1.26	-0.31	-2.01	25.16	11.57
16.	RK918506 x Mathura Rai	-2.25	0.07	-1.09	47.30**	39.73**	43.51**
17.	RK911296 x Mathura Rai	-23.00**	13.97**	-4.51**	-13.10*	21.19*	4.04*
18.	RK9 x Mathura Rai	10.24**	7.27**	8.75**	-19.84*	5.96**	-6.94**
19.	RK14 x Mathura Rai	-5.49**	4.47**	-0.51**	6.45	39.73	23.09
20.	KRV 47 x Mathura Rai	16.42**	4.63**	10.52**	31.45**	-5.96**	12.64**
21.	RK8601 x Laha 101	-5.50**	0.22**	-2.64**	4.29	37.09**	20.99
22.	RK8602 x Laha 101	-7.36**	-4.12**	-5.74**	-70.89**	-33.77**	-52.33**
23	RK8604 x Laha 101	15.05**	1.45**	8.25**	-20.22**	-23.18**	-51.70**
24	RK8605 x Laha 101	9.49	2.07**	5.78**	11.21	-3.31	3.95
25	RK8608 x Laha 101	-18.75	-13.38**	-16.06**	- 24.59**	2.65**	-10.97**
26.	RK8701 x Laha 101	1.26	0.57	0.91	12.69*	12.58*	12.63*
27.	RK8702 x Laha 101	-5.59*	14.33*	4.37*	-27.83**	3.31**	12.26**
28.	RK8801 x Laha 101	-8.16**	-4.85**	-6.50**	31.20**	4.63**	13.28**
29.	RK8802 x Laha 101	-9.12**	10.80**	0.84**	-59.05**	-11.92**	-35.48**
30.	RK8803 x Laha 101	16.27**	-5.07**	5.60**	-53.77**	-10.59**	-32.18**
31.	RK8901 x Laha 101	12.41**	7.27**	9.84**	0.59	40.39	20.47
32.	RK8902 x Laha 101	1.87	10.01**	5.94	52.49**	51.65**	14.96**
33.	RK8903 x Laha 101	15.53**	4.25**	9.89**	-8.48	38.41	14.96
34.	RL9001 x Laha 101	4.97*	9.26**	7.10**	-14.91*	-4.63*	-9.77*
35.	RK9002 x Laha 101	13.23**	1.32**	7.27**	26.72**	-2.65**	12.03**
36.	RK918506 x Laha 101	3.87**	2.64*	3.25**	-12.75	-13.90	-13.32
37.	RK911296 x Laha 101	2.87	-4.72	0.92	32.89**	27.81**	30.35**
38.	RK9 x Laha 101	11.76**	-1.19**	5.28**	14.93*	11.92*	13.42*
39.	RK14 x Laha 101	-1.53	-15.29	-8.42	-2.08	20.53	18.53
40.	KRV 47 x Laha 101	-0.32	-7.58	-3.25	-39.72**	17.88**	-10.92**
41.	RK8601 xVaibhav	-5.49*	-1.63**	-3.56**	43.71**	17.22**	30.46**
42.	RK8602 xVaibhav	-16.45**	-8.15**	-12.30**	-36.57**	11.92**	-12.32**
43.	RK8604 xVaibhav	0.00	-11.77	-5.88	-66.14**	5.96**	30.09**
44	RK8605 xVaibhav	9.73**	6.02**	7.87**	-44.80**	4.63**	-20.08**
45.	RK8608 xVaibhav	7.11**	-1.85**	2.63**	-11.96	-1.99	-6.97
46.	RK8701 xVaibhav	1.41	-2.14**	-0.36	-43.86**	-3.97**	-23.91**
47.	RK8702 xVaibhav	-4.09*	-11.24*	-7.66*	-11.11	-1.32	-6.21
48.	RK8801 xVaibhav	-3.25	-14.63	-8.94	9.52	5.29	7.40
49.	RK8802 xVaibhav	-4.26*	-7.20*	-5.73*	-9.26	-9.93	-9.59
50.	RK8803 xVaibhav	-12.79**	-15.36**	-14.07**	-8.49	-10.59	-9.54
51.	RK8901 xVaibhav	-7.47**	-3.68**	-5.57**	-105.76	-13.24**	-59.50
52.	RK8902 xVaibhav	-3.16	-16.84	-10.00	-15.69*	-14.56*	-15.12*
53.	RK8903 xVaibhav	-1.89	-3.94	-2.91	2.56	-1.32	0.62
54.	RL9001 xVaibhav	-1.86	-7.42**	-4.64	12.03*	11.92*	11.97*
55.	RK9002 xVaibhav	-19.33**	-13.16**	-15.74**	-86.96**	-41.72**	-64.34**
56.	RK918506 xVaibhav	-6.50*	-7.80	-7.15	-00.98	-13.91	-7.44
57.	RK911296 xVaibhav	3.96*	-1.54	-2.75	-9.63	13.24	1.80
58.	RK9 x Vaibhav	-2.14	3.53	0.69	-2.70	23.84	10.57
59.	RK14 xVaibhav	14.08**	6.39**	10.23**	-10.38	11.26	0.44
60.	KRV 47 xVaibhav	2.41	0.81	1.61	-101.51**	-44.37**	-72.94**
	SE [Diff. ≡(±)]	1.60	0.81	0.89	0.08	0.10	0.07

Table 8b : Contd.

		Inbreeding depression over best parent					
		Yield per plant			Oil content		
S.N.	Crosses	E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	33.34**	42.27**	37.80**	2.56	18.33	10.44
2.	RK8602 x Mathura Rai	58.08**	154.28**	106.18**	13.94**	19.06**	16.30**
3.	RK8604 x Mathura Rai	02.19	32.31	17.25	5.46*	18.98	12.22
4.	RK8605 x Mathura Rai	-17.72**	39.17**	10.97**	50.4*	12.82	8.93
5.	RK8608 x Mathura Rai	60.39**	197.26**	128.82**	19.79**	14.18**	16.98**
6.	RK8701 x Mathura Rai	20.00**	18.55**	19.27**	21.89**	13.64**	17.76**
7.	RK8702 x Mathura Rai	-00.80**	23.71	11.45	3.36	13.79	8.57
8.	RK8801 x Mathura Rai	47.37**	159.43**	128.37**	-22.71**	10.31	-6.20
9.	RK8802 x Mathura Rai	15.04**	49.48**	32.26**	3.70	8.91	6.30
10.	RK8803 x Mathura Rai	40.79**	75.26**	58.02**	9.00**	15.49	12.24
11.	RK8901 x Mathura Rai	35.96**	35.72**	35.84**	-9.75**	6.97*	1.39**
12.	RK8902 x Mathura Rai	13.47**	39.17**	26.32**	15.94**	17.01**	16.47**
13.	RK8903 x Mathura Rai	36.24**	34.02**	35.13**	-22.13**	13.48	-4.82
14.	RL9001 x Mathura Rai	60.47**	37.47**	48.97**	-3.19	4.88	0.84
15.	RK9002 x Mathura Rai	16.56*	70.10**	43.33**	0.85	8.09	4.47
16.	RK918506 x Mathura Rai	-98.06**	80.41**	36.17**	7.16**	11.27	9.21
17.	RK911296 x Maathura Rai	42.50**	95.87**	69.18**	-8.23**	8.83	0.30
18.	RK9 x Mathura Rai	-17.66**	10.96**	-3.35**	-3.18	8.02	2.42
19.	RK14 x Mathura Rai	51.89**	133.66**	92.77**	-0.55	10.53	4.99
20.	KRV 47 x Mathura Rai	12.82**	135.11**	73.96**	-9.66**	9.34*	-0.16**
21.	RK8601 x Laha 101	43.87**	147.42**	95.64**	12.94**	18.32**	15.64**
22.	RK8602 x Laha 101	-19.53**	64.95**	22.71**	-3.75	7.32	1.78
23	RK8604 x Laha 101	15.19**	54.64**	34.91**	-5.86**	5.19	-0.33
24	RK8605 x Laha 101	29.39**	138.81**	84.10**	5.60*	9.88	7.74
25	RK8608 x Laha 101	35.47**	37.47**	36.47*/*	-21.02**	-4.45**	-12.73**
26.	RK8701 x Laha 101	12.04**	61.49**	36.76**	-2.16	9.72	3.78
27.	RK8702 x Laha 101	38.23**	32.32**	35.27**	9.65**	15.15*	12.40**
28.	RK8801 x Laha 101	-35.71**	-19.23**	-27.47**	2.38	6.97	4.67
29.	RK8802 x Laha 101	39-01**	78.71**	58.86**	4.14	11.19	7.66
30.	RK8803 x Laha 101	35.65**	76.96**	56.30**	6.78*	11.58	9.18
31.	RK8901 x Laha 101	38.59**	92.42**	65.50**	-5.40*	10.77	2.68
32.	RK8902 x Laha 101	28.46**	27.16**	27.81**	13.49**	13.87**	13.68**
33.	RK8903 x Laha 101	-9.93*	46.03*	18.05*	5.21*	10.38	7.79
34.	RL9001 x Laha 101	-1.13	-49.48	-25.30	11.62**	15.57*	13.59**
35.	RK9002 x Laha 101	-16.94**	20.26**	1.66**	-3.08	4.96	0.94
36.	RK918506 x Laha 101	-37.69**	20.26**	8.71**	6.85**	21.66	14.25
37.	RK911296 x Laha 101	-36.34**	-26.13**	31.23**	9.35**	16.85*	13.10**
38.	RK9 x Laha 101	-16.89**	32.31**	7.71**	-7.13*	7.44	0.15
39.	RK14 x Laha 101	57.96**	82.11**	69.93**	10.05**	6.70	8.37
40.	KRV 47 x Laha 101	74.92**	231.59**	153.25**	2.06	5.27	3.66
41.	RK8601 xVaibhav	60.93**	10.96**	35.94**	-7.26*	12.47	2.60
42.	RK8602 xVaibhav	53.09**	63.25**	57.67**	11.33**	19.376*	15.54**
43.	RK8604 xVaibhav	70.14**	169.74**	119.94**	16.89**	15.81**	16.35**
44	RK8605 xVaibhav	37.67**	34.02**	35.84**	6.91*	6.74	6.82
45.	RK8608 xVaibhav	65.66**	126.80**	96.23**	-18.47**	3.89**	-7.29**
46.	RK8701 xVaibhav	50.94**	52.94**	51.94**	12.96**	11.35*	12.15**
47.	RK8702 xVaibhav	52.44**	59.79**	56.11**	-3.93	8.91	2.49
48.	RK8801 xVaibhav	37.50**	32.32**	34.91**	-29.41**	-2.17**	-15.79**
49.	RK8802 xVaibhav	42.66**	39.17**	40.91**	-19.90**	0.08**	-9.91**
50.	RK8803 xVaibhav	44.68**	35.72**	40.20**	8.41**	15.88	12.14
51.	RK8901 xVaibhav	35.53**	18.53**	27.04**	-3.01	1.05	-0.98
52.	RK8902 xVaibhav	42.73**	20.26**	31.49**	7.07**	9.88	8.47
53.	RK8903 xVaibhav	45.73**	37.47**	41.60**	6.01*	10.38	8.19
54.	RL9001 xVaibhav	39.83**	30.57**	35.20 **	-7.76*	-0.66	-4.21
55.	RK9002 xVaibhav	48.29**	40.87**	44.58**	-29.30**	-0.35**	-14.82**
56.	RK918506 xVaibhav	30.77**	1.39	16.08	-23.99**	-2.71**	-13.35**
57.	RK911296 xVaibhav	47.82**	35.72**	41.77**	-1.52	2.83	0.65
58.	RK9 x Vaibhav	31.62**	15.10**	23.36**	4.33*	15.26	9.79
59.	RK14 xVaibhav	25.23**	1.39**	13.31**	-16.28**	0.00	-8.14
60.	KRV 47 xVaibhav`	38.85**	35.72**	35.78**	-6.43*	5.50	-0.46
	SE [Diff. ≅(±)]	1.92	1.13	1.11	0.94	0.85	0.63

Table 8b : Contd.

		Inbreeding depression over best parent		
		Erucic acid		
S.N.	Crosses	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	0.61	-2.48	-1.55
2.	RK8602 x Mathura Rai	1.28	-1.85	-1.57
3.	RK8604 x Mathura Rai	2.41*	-2.48	-2.45
4.	RK8605 x Mathura Rai	2.41*	-1.23	1.82
5.	RK8608 x Mathura Rai	1.81	-1.85	-1.83
6.	RK8701 x Mathura Rai	1.81	-1.23	1.52
7.	RK8702 x Mathura Rai	0.61	-3.92	-2.27
8.	RK8801 x Mathura Rai	1.22	-4.55	-2.89
9.	RK8802 x Mathura Rai	0.16	-4.76	-2.46
10.	RK8803 x Mathura Rai	0.55	-4.76	-2.66
11.	RK8901 x Mathura Rai	3.46**	-3.29	3.38*
12.	RK8902 x Mathura Rai	0.61	-2.60	-1.61
13.	RK8903 x Mathura Rai	1.81	-1.85	-1.83
14.	RL9001 x Mathura Rai	0.00	-3.27	-1.64
15.	RK9002 x Mathura Rai	0.61	-5.39*	-3.00
16.	RK918506 x Mathura. Rai	0.00	-3.29	-1.65
17.	RK911296 x Mathura Rai	0.61	-1.86	-1.24
18.	RK9 x Mathura Rai	0.00	-2.48	-1.24
19.	RK14 x Mathura Rai	0.00	-1.85	-0.93
20.	KRV 47 x Mathura Rai	0.21	-1.23	-1.22
21.	RK8601 x Laha 101	0.00	-3.27	-1.64
22.	RK8602 x Laha 101	1.22	-7.62**	-4.42**
23	RK8604 x Laha 101	0.61	-6.27**	-3.44
24	RK8605 x Laha 101	0.00	-4.09	2.05
25	RK8608 x Laha 101	0.47	-3.27	-1.87
26.	RK8701 x Laha 101	0.61	-1.23	-0.92
27.	RK8702 x Laha 101	0.00	-1.23	-0.62
28.	RK8801 x Laha 101	0.61	-3.29	-1.95
29.	RK8802 x Laha 101	1.21	-5.39*	-3.30
30.	RK8803 x Laha 101	1.21	-3.29	-2.25
31.	RK8901 x Laha 101	1.21	-8.89	-3.84*
32.	RK8902 x Laha 101	0.62	-6.27**	-2.83
33.	RK8903 x Laha 101	0.62	-4.73	-2.06
34.	RL9001 x Laha 101	0.00	-2.01	-1.01
35.	RK9002 x Laha 101	0.61	-3.27	-1.33
36.	RK918506 x Laha 101	1.21	-4.76	-1.78
37.	RK911296 x Laha 101	0.00	-7.78**	-3.89*
38.	RK9 x Laha 101	-0.61	-6.92**	-3.77*
39.	RK14 x Laha 101	0.09	-2.64	-1.27
40.	KRV 47 x Laha 101	-1.23	-4.76	-2.99
41.	RK8601 xVaibhav	-0.62	-4.76	-2.69
42.	RK8602 xVaibhav	-0.61	-3.29	-1.95
43.	RK8604 xVaibhav	-0.57	-3.34	-1.96
44	RK8605 xVaibhav	-0.57	-3.34	-1.96
45.	RK8608 xVaibhav	-0.61	-1.89	-1.25
46.	RK8701 xVaibhav	-0.61	-2.68	-1.65
47.	RK8702 xVaibhav	-0.63	-2.68	-1.66
48.	RK8801 xVaibhav	-0.61	-1.25	-0.93
49.	RK8802 xVaibhav	0.00	-7.62**	-3.81
50.	RK8803 xVaibhav	0.00	-2.63	-1.31
51.	RK8901 xVaibhav	1.22	-4.09	-1.44
52.	RK8902 xVaibhav	0.61	-4.09	-1.74
53.	RK8903 xVaibhav	0.61	-3.44	-1.42
54.	RL9001 xVaibhav	0.61	-6.23**	-3.42*
55.	RK9002 xVaibhav	1.36	-8.48**	-3.56*
56.	RK918506 xVaibhav	0.00	-2.83	-1.42
57.	RK911296 xVaibhav	-0.62	-5.59*	-3.11
58.	RK9 x Vaibhav	-0.62	-3.44	-0.81
59.	RK14 xVaibhav	0.00	-6.23**	-3.12
60.	KRV 47 xVaibhav	0.00	-2.62	-1.31
	SE [Diff. ≅ (+)]	0.55	0.72	0.69

* Significant at p=0.05 ** Significant at p=0.01

Table 9: **Grand mean, heritability estimates genetic advance and genetic advance in percent of mean in two environments alongwith pooled values for 13 characters in F_1 and F_2 generation of Indian mustard.**

	Character	Grand mean [$\bar{X}$]					
		F_1			F_2		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	Days of flowering	36.52	35.25	35.88	36.38	33.78	35.08
2.	Days to reproductive phase	90.12	74.02	82.07	90.62	63.82	77.22
3.	No. of primary branches	07.99	5.99	6.99	6.41	4.86	5.63
4.	No. of secondary branches	21.17	11.56	16.36	17.29	9.46	13.37
5.	Height of plant	150.80	137.64	148.22	162.68	140.47	151.58
6.	Length of main fruiting br.	701.44	41.46	56.44	58.37	40.00	49.19
7.	No. of siliquae on main fr. br.	51.38	27.92	39.65	49.42	26.80	38.14
8.	Days to maturity	136.53	108.24	117.39	117.08	102.97	110.03
9.	Relative water content	85.27	43.52	64.39	84.88	43.38	64.12
10.	Leaf water potential	1.24	1.57	1.40	1.34	1.70	1.52
11.	Yield per plant	49.99	28.18	39.09	36.16	20.53	28.35
12.	Oil content	37.59	27.24	32.41	37.22	27.08	32.15
13.	Erucic acid	15.64	49.12	49.88	50.60	51.05	50.2

	Character	Heritability [$\hat{h}^2$] Per cent					
		F_1			F_2		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	Days of flowering	36.26	38.52	32.25	36.12	43.32	30.04
2.	Days to reproductive phase	32.98	31.04	25.85	32.54	90.18	36.71
3.	No. of primary branches	11.20	9.80	7.30	23.20	24.50	22.40
4.	No. of secondary branches	18.70	21.90	25.40	23.70	23.90	1.40
5.	Height of plant	32.60	39.93	30.45	34.64	NV	34.80
6.	Length of main fruiting br.	12.23	14.69	30.52	NV	24.70	18.90
7.	No. of siliquae on main fr. br.	10.40	9.70	8.90	11.70	11.20	1.70
8.	Days to maturity	31.81	39.35	34.88	36.00	47.25	33.58
9.	Relative water content	9.80	12.40	10.70	NV	7.50	8.40
10.	Leaf water potential	12.40	17.30	20.20	10.70	13.90	11.60
11.	Yield per plant	11.70	9.40	7.40	22.20	22.40	11.90
12.	Oil content	6.40	7.60	10.20	NV	NV	8.20
13.	Erucic acid	41.66	37.50	42.30	38.09	33.33	30.00

Table 9. Contd.

Character		Genetic advance [GA]					
		F_1			F_2		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	Days of flowering	3.23	2.98	4.68	2.93	3.36	3.38
2.	Days to reproductive phase	4.41	2.93	4.12	3.98	1.58	5.59
3.	No. of primary branches	0.76	1.43	0.56	0.92	1.14	0.98
4.	No. of secondary branches	3.87	2.43	5.78	2.99	1.60	2.52
5.	Height of plant	12.54	23.98	21.42	10.33	23.02	15.77
6.	Length of main fruiting br.	3.74	2.48	5.69	NV	4.44	7.20
7.	No. of siliquae on main fr. Br.	3.26	1.79	2.83	3.29	2.10	3.03
8.	Days to maturity	5.52	4.59	9.80	4.87	7.53	11.39
9.	Relative water content	1.93	1.32	2.36	NV	NV	1.89
10.	Leaf water potential	0.96	0.17	0.26	0.11	0.17	0.20
11.	Yield per plant	7.64	3.50	5.09	9.54	5.42	5.66
12.	Oil content	0.92	0.64	1.25	NV	NV	0.75
13.	Erucic acid	0.50	0.35	1.03	0.41	0.31	0.44

Character		Genetic advance in per cent over mean					
		F_1			F_2		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	Days of flowering	8.80	8.42	13.03	8.06	9.94	10.65
2.	Days to reproductive phase	4.89	3.96	5.02	4.39	2.48	7.24
3.	No. of primary branches	9.51	23.87	8.01	14.35	23.45	17.40
4.	No. of secondary branches	17.77	21.02	35.33	17.29	16.91	18.84
5.	Height of plant	7.89	17.42	14.45	NV	16.39	10.40
6.	Length of main fruiting br.	5.23	5.98	10.08	8.42	11.09	14.64
7.	No. of siliquae on main fr.br.	6.34	6.41	7.13	6.65	7.81	7.94
8.	Days to maturity	4.13	4.17	8.35	4.16	7.31	9.85
9.	Relative water content	2.26	3.03	3.66	NV	NV	2.94
10.	Leaf water potential	7.74	10.82	18.57	8.20	10.10	13.15
11.	Yield per plant	15.28	12.42	13.02	26.38	26.40	19.96
12.	Oil content	2.45	2.35	3.85	NV	NV	2.35
13.	Erucic acid	0.99	0.70	2.08	0.81	0.61	0.86

NV = Negative Value

Table 10 a: Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients among 13 characters in two environment (E_1 and E_2) alongwith pooled values in 60 F_1s of Indian mustard [F_1's in E_1 (Normal sown)]

Character	Days to flowering	Days to reproductive phase	No. of primary branches	No. of secondary branches	Height of plant	Length of main fruiting branch	No. of siliquae on main fruiting branches	Days to maturity	Relative water content	Leaf water potential	Yield per plant	Oil content	Erucic acid
Days to flowering	**$g^r p$**	0.01	-0.12	-0.11	0.01	-0.15	-0.10	-0.01	0.11	0.01	-0.28*	-0.29*	0.38**
Days to reproductive phase	0.04	**$g^r p$**	0.08	0.01	0.01	-0.16	0.31*	0.11	0.15	-0.28*	0.14	0.12	-0.09
No. of primary branches	-0.23	0.11	**$g^r p$**	0.56**	0.11	0.01	0.09	-0.02	-0.03	0.01	0.36**	0.14	-0.29*
No. of secondary branches	-0.12	-0.01	0.74	**$g^r p$**	-0.16	-0.04	0.06	0.13	-0.02	0.28*	0.49**	0.39**	-0.27*
Height of plant	-0.01	0.02	0.11	-0.18	**$g^r p$**	0.01	0.17	-0.12	0.04	-0.28*	-0.32*	-0.83**	0.06
Length of main fruiting branch	-0.19	-0.17	0.04	-0.04	0.01	**$g^r p$**	0.30*	-0.03	-0.03	0.10	0.06	-0.01	0.05
No. of siliquae on main fruiting branch	-0.11	0.34	0.14	0.07	0.22	0.32	**$g^r p$**	0.35**	0.06	-0.03	-0.01	-0.16	0.08
Days to maturity	0.05	0.09	-0.01	0.14	-0.14	-0.03	0.16	**$g^r p$**	0.04	0.28*	0.12	0.13	-0.08
Relative water content	0.13	0.16	-0.06	-0.02	0.04	-0.03	0.06	0.04	**$g^r p$**	0.04	0.19	-0.02	-0.07
Leaf water potential	0.04	-0.19	0.04	0.20	-0.25	0.11	-0.03	0.21	0.08	**$g^r p$**	0.09	0.20	-0.06
Yeild per plant	-0.35	0.14	0.43	0.52	-0.24	0.06	-0.01	0.13	0.11	0.11	**$g^r p$**	0.47**	-0.38**
Oil content	-0.23	0.13	0.207	0.38	-0.81	-0.02	-0.17	0.14	-0.01	0.21	0.49	**$g^r p$**	-0.42**
Erucic acid	0.43	-0.23	-0.56	-0.46	0.04	0.13	0.11	-0.21	-0.09	-0.07	-0.50	-0.64	**$g^r p$**

Table 10a: Contd.

[F_1s in E_2 (Late sown)]

Character	Days to flowering	Days to reproductive phase	No. of primary branches	No. of secondary branches	Height of plant	Length of main fruiting branch	No. of siliquae on main fruiting branches	Days to maturity	Relative water content	Leaf water potential	Yield per plant	Oil content	Erucic acid
Days to flowering	$g\ ^{r}p$	0.16	0.02	-0.11	-0.01	-0.03	0.13	-0.11	0.11	-0.01	-0.31*	-0.50**	0.39**
Days to reproductive phase	0.21	$g\ ^{r}p$	-0.06	-0.01	0.07	-0.37**	0.32*	0.12	0.17	-0.29*	0.04	0.13	-0.29*
No. of primary branches	00.02	-0.11	$g\ ^{r}p$	0.38**	0.01	0.02	0.35**	-0.05	-0.12	-0.07	0.27*	-0.08	0.12
No. of secondary branches	-0.11	-0.02	0.51	$g\ ^{r}p$	-0.28*	-0.05	0.08	0.13	-0.02	0.16	0.48**	0.29*	-0.35**
Height of plant	-0.03	0.07	-0.03	-0.37	$g\ ^{r}p$	0.29*	0.14	0.10	0.02	-0.36**	-0.36*	0.36**	0.29*
Length of main fruiting branch	-0.07	-0.19	0.04	-0.05	0.29	$g\ ^{r}p$	0.12	0.03	-0.01	0.02	0.31*	-0.04	0.17
No. of siliquae on main fruiting branch	0.17	0.29	0.38	0.08	0.19	0.14	$g\ ^{r}p$	-0.04	-0.03	-0.15	-0.10	-0.13	0.32*
Days to maturity	-0.13	0.13	-0.05	0.14	0.12	0.02	-0.04	$g\ ^{r}p$	0.05	0.10	0.28*	0.39**	-0.32*
Relative water content	0.12	0.19	-0.16	-0.02	0.05	-0.01	-0.03	0.05	$g\ ^{r}p$	0.05	0.28*	0.04	0.41**
Leaf water potential	0.03	-0.20	-0.09	0.18	-0.21	0.03	-0.17	0.11	0.09	$g\ ^{r}p$	0.11	0.12	-0.03
Yeild per plant	-0.24	0.04	0.29	0.52	-0.19	0.35	-0.11	0.34	0.08	0.13	$g\ ^{r}p$	0.40**	-0.44**
Oil content	-0.07	0.14	-0.13	0.34	-0.46	-0.04	-0.15	0.27	0.04	0.13	0.45	$g\ ^{r}p$	-0.56**
Erucic acid	0.37	-0.22	0.05	-0.41	0.29	0.14	0.24	-0.36	0.02	-0.03	-0.51	-0.67	$g\ ^{r}p$

Table 10 a: Contd.
[F_1 s in pooled ($E_1 + E_2$)]

Character	Days to flowering	Days to reproductive phase	No. of primary branches	No. of secondary branches	Height of plant	Length of main fruiting branch	No. of siliquae on main fruiting branches	Days to maturity	Relative water content	Leaf water potential	Yield per plant	Oil content	Erucic acid
Days to flowering	$g^r p$	0.08	-0.03	-0.10	-0.01	-0.11	0.01	-0.28*	-0.11	-0.01	-0.28*	-0.12	0.28*
Days to reproductive phase	0.13	$g^r p$	0.01	-0.01	0.06	-0.11	0.38**	0.14	0.28*	-0.32**	0.10	0.29*	-0.26*
No. of primary branches	-0.09	0.01	$g^r p$	0.46**	-0.03	0.01	0.32*	0.12	-0.08	-0.03	0.28*	-0.02	-0.29*
No. of secondary branches	-0.11	-0.01	0.65	$g^r p$	-0.32*	-0.05	0.28*	0.34*	-0.02	0.18*	0.48**	0.33*	-0.30*
Height of plant	-0.04	0.08	-0.10	-0.44	$g^r p$	0.18	0.29*	-0.09	0.04	-0.29*	-0.33*	-0.74**	0.16
Length of main fruiting branch	-0.16	-0.12	0.03	-0.05	0.26	$g^r p$	0.30*	0.19	-0.02	0.09	0.34*	-0.06	0.08
No. of siliquae on main fruiting branch	0.03	0.43	0.35	0.30	0.32	0.35	$g^r p$	0.29*	0.01	-0.10	-0.07	-0.31*	0.16
Days to maturity	-0.23	0.15	0.21	0.28	-0.15	0.23	0.37	$g^r p$	0.08	0.32*	0.39**	0.43**	-0.35**
Relative water content	0.12	0.23	-0.13	-0.02	0.06	-0.02	0.02	0.09	$g^r p$	0.34*	0.09	0.02	-0.03
Leaf water potential	0.02	-0.25	-0.02	0.20	-0.29	0.10	-0.11	0.28	0.08	$g^r p$	0.01	0.29*	-0.05
Yeild per plant	-0.23	0.01	-0.29	0.51	-0.29	0.38	-0.08	0.46	0.09	0.12	$g^r p$	0.46**	-0.38**
Oil content	-0.15	0.29	-0.13	0.39	-0.97	-0.06	-0.37	0.52	0.02	0.29	0.49	$g^r p$	-0.51**
Erucic acid	0.35	-0.28	-0.34	-0.42	0.25	0.11	0.21	-0.42	-0.02	-0.05	-0.51	-0.68	$g^r p$

*** Significant at $p = 0.05$; ** Significant at $p = 0.01$**

Table 10b: Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients among 13 characters in two environments [E_1 and E_2] alongwith pooled values in 60 F_2s population of Indian mustard [F_2's in E_1 (Normal sown)]

Character	Days to flowering	Days to reproductive phase	No. of primary branches	No. of secondary branches	Height of plant	Length of main fruiting branch	No. of siliquae on main fruiting branches	Days to maturity	Relative water content	Leaf water potential	Yield per plant	Oil content	Erucic acid
Days to flowering	$g^r p$	-0.15	0.02	-0.01	0.03	0.04	0.30*	0.02	-0.10	0.01	-0.29*	0.28*	0.29*
Days to reproductive phase	-0.23	$g^r p$	0.04	0.14	-0.11	0.03	0.28*	-0.15	0.12	-0.09	0.01	0.29*	0.17
No. of primary branches	0.13	0.09	$g^r p$	0.38**	0.05	-0.03	0.29*	-0.36*	0.12	0.01	0.32*	-0.08	0.06
No. of secondary branches	0.01	0.14	0.74	$g^r p$	-0.13	0.01	0.31*	-0.06	0.16	-0.09	0.38**	0.09	-0.05
Height of plant	0.01	-0.11	0.09	-0.15	$g^r p$	-0.02	0.29*	0.07	-0.11	0.17	-0.29*	-0.75**	0.07
Length of main fruiting branch	0.07	0.04	0.01	-0.02	-0.02	$g^r p$	0.44**	-0.06	0.27*	-0.04	0.33*	-0.32*	0.10
No. of siliquae on main fruiting branch	0.34	0.32	0.34	0.37	0.32	0.51	$g^r p$	-0.03	-0.09	-0.29*	0.11	-0.17	0.19
Days to maturity	0.04	-0.18	-0.27	-0.09	0.07	-0.05	-0.04	$g^r p$	-0.15	0.36*	-0.13	-0.32*	-0.04
Relative water content	-0.15	0.12	0.19	0.17	-0.13	0.30	-0.09	-0.16	$g^r p$	-0.01	0.34	0.07	0.03
Leaf water potential	-0.03	-0.09	0.05	-0.09	0.21	-0.05	0.32	0.41	0.01	$g^r p$	-0.03	0.30*	-0.19
Yeild per plant	-0.07	0.01	0.37	0.44	-0.17	0.39	0.10	-0.14	0.37	-0.03	$g^r p$	0.19	-0.11
Oil content	-0.32	0.29	-0.13	0.10	-0.73	0.35	-0.19	-0.35	0.07	0.36	0.21	$g^r p$	-0.50**
Erucic acid	0.44	-0.29	0.06	-0.14	0.03	0.01	0.25	-0.13	-0.03	-0.28	-0.16	-0.74	$g^r p$

Table 10b: Contd.

[F_2's in E_2 (Late sown)].

Character	Days to flowering	Days to reproductive phase	No. of primary branches	No. of secondary branches	Height of plant	Length of main fruiting branch	No. of siliquae on main fruiting branches	Days to maturity	Relative water content	Leaf water potential	Yield per plant	Oil content	Erucic acid
Days to flowering	$g^r p$	0.06	0.12	0.01	0.14	0.04	0.28*	-0.04	-0.12	-0.01	-0.29*	-0.16	0.28*
Days to reproductive phase	0.07	$g^r p$	-0.15	0.05	-0.05	-0.13	0.37**	0.07	0.15	-0.11	-0.08	0.20	-0.21
No. of primary branches	0.28	-0.23	$g^r p$	0.29*	0.17	0.15	0.36**	-0.37**	-0.04	-0.13	0.27*	-0.28*	0.41**
No. of secondary branches	0.01	0.03	0.41	$g^r p$	-0.28*	0.08	0.28*	-0.07	0.15	-0.09	0.37**	0.10	-0.04
Height of plant	0.19	-0.13	0.20	-0.30	$g^r p$	0.30*	0.29*	0.16	-0.03	0.01	-0.29*	-0.40**	0.36**
Length of main fruiting branch	0.02	-0.14	0.19	0.10	0.30	$g^r p$	0.28*	-0.01	0.33*	-0.01	0.30*	-0.04	0.28*
No. of siliquae on main fruiting branch	0.33	0.37**	0.51	0.31	0.34	0.35	$g^r p$	-0.12	-0.13	-0.29*	0.08	-0.09	0.27*
Days to maturity	-0.14	0.10	-0.27	-0.11	0.19	-0.01	-0.14	$g^r p$	-0.04	0.36**	0.07	0.13	-0.28*
Relative water content	-0.16	0.17	-0.04	0.17	-0.03	0.15	-0.14	-0.86	$g^r p$	-0.05	0.33*	0.07	0.01
Leaf water potential	-0.03	-0.12	-0.17	-0.09	0.01	-0.01	-0.21	0.15	-0.04	$g^r p$	-0.01	0.36**	-0.29*
Yeild per plant	-0.18	0.28	0.31	0.44	-0.32	0.32	0.07	0.09	0.02	-0.02	$g^r p$	0.16	-0.15
Oil content	-0.18	-0.23	-0.40	0.15	-0.53	-0.03	-0.09	0.20	0.08	0.04	0.17	$g^r p$	-0.56**
Erucic acid	-0.34	-0.26	-0.59	-0.06	0.41	0.22	0.37	-0.37	0.02	-0.28	-0.16	-0.71	$g^r p$

Table 10b: Contd.

[F_2's in pooled $E_1 + E_2$].

Character	Days to flowering	Days to reproductive phase	No. of primary branches	No. of secondary branches	Height of plant	Length of main fruiting branch	No. of siliquae on main fruiting branches	Days to maturity	Relative water content	Leaf water potential	Yield per plant	Oil content	Erucic acid
Days to flowering	$g\ ^r p$	-0.05	0.38**	0.01	0.11	0.03	0.11	-0.07	-0.11	0.01	-0.28*	-0.29*	0.39**
Days to reproductive phase	-0.08	$g\ ^r p$	-0.20	0.10	-0.30*	0.05	0.38**	-0.09	-0.19	-0.14	-0.09	0.39**	-0.35**
No. of primary branches	0.24	-0.20	$g\ ^r p$	0.31	0.03	0.06	0.33*	-0.09	0.03	-0.06	0.30*	-0.26	0.29**
No. of secondary branches	0.01	0.10	0.59	$g\ ^r p$	-0.36**	0.04	0.28*	-0.09	0.15	-0.09	0.36**	0.34*	-0.03
Height of plant	0.14	-0.22	0.01	-0.33	$g\ ^r p$	0.11	0.29*	0.05	-0.07	0.09	-0.36**	-0.82**	0.23
Length of main fruiting branch	0.04	0.05	0.15	0.04	0.18	$g\ ^r p$	0.44**	0.07	0.16	-0.04	0.28*	-0.07	0.35*
No. of siliquae on main fruiting branch	0.18	0.42	0.37	0.31	0.32	0.57	$g\ ^r p$	0.02	-0.13	-0.17	0.12	-0.34*	0.29*
Days to maturity	-0.21	-0.09	-0.24	-0.20	0.05	0.17	0.05	$g\ ^r p$	-0.11	0.13	0.03	0.37*	-0.16
Relative water content	-0.15	0.19	0.04	0.17	-0.08	0.21	-0.16	-0.19	$g\ ^r p$	-0.03	0.35**	0.07	-0.01
Leaf water potential	-0.02	-0.14	-0.08	-0.10	0.12	-0.05	-0.18	0.22	-0.02	$g\ ^r p$	-0.02	0.28*	-0.29*
Yeild per plant	-0.07	-0.08	0.34	0.42	-0.28	0.31	0.12	0.05	0.03	-0.02	$g\ ^r p$	0.29*	-0.33*
Oil content	-0.25	0.39	-0.46	0.38	-0.96	-0.09	-0.39	0.38	0.08	0.31	0.32	$g\ ^r p$	-0.56**
Erucic acid	0.34	-0.35	0.37	-0.08	0.31	0.23	0.39	-0.36	0.01	-0.26	-0.16	-0.75	$g\ ^r p$

*** Significant at $p = 0.05$; ** Significant at $p = 0.01$**

Table 10c: Direct and indirect effects (Path Coefficient Analysis) at genotypic level for oil yield Vs. other 12 characters in two environments (E_1 and E_2) alongwith their pooled values in 60 F_1s of Indian mustard [F_1s in E_1 (Normal sown)]

Character	Days to flowering	Days to reproductive phase	No. of primary branches	No. of secondary branches	Height of plant	Length of main fruiting branch	No. of siliquae on main fruitin branches	Days to maturit	Relative water content	Leaf water potential	Yield per plant	Erucic acid	Genotypic correlation wit yield (Oil content)
Days to flowering	**0.13**	-0.01	0.03	0.01	-.0.01	-0.01	-0.01	-0.01	-0.10	0.01	- 0.01	-0.34	-0.32
Days to reproductive phase	0.01	**-0.03**	-0.01	0.01	-0.02	-0.01	0.03	-0.01	-0.02	-0.01	0.01	0.18	0.13
No. of primary branches	-0.030	-0.002	**-0.121**	-0.021	-0.090	-0.001	0.021	0.001	-0.001	-0.001	0.00 1	0.451	0.207
No. of secondary branches	-0.02	0.01	-0.09	**-0.03**	0.15	-0.01	0.01	-0.02	0.01	-0.01	0.01	0.37	0.38
Height of plant	0.01	-0.01	-0.01	0.01	**-0.82**	0.01	0.03	0.02	-0.01	0.01	- 0.01	-0.03	-0.82
Length of main fruiting branch	-0.02	0.01	-0.02	0.01	-0.01	**0.07**	0.04	0.01	0.02	-0.01	0.02	-0.10	0.02
No. of siliquae on main fruiting branch	-0.011	-0.012	-0.021	-0.013	-0.182	0.028	**0.110**	-0.031	0.011	0.012	0.01 1	0.081	-0.017
Days to maturity	0.01	-0.01	0.01	-0.01	0.11	0.01	0.02	**-0.16**	-0.01	-0.01	0.01	0.17	0.14
Relative water content	0.02	-0.01	0.01	0.01	0.03	-0.01	0.01	-0.01	**-0.07**	-0.01	0.01	0.07	-0.05
Leaf water potential	0.01	0.01	-0.01	-0.01	0.20	0.01	-0.01	-0.03	-0.01	**-0.02**	0.01	0.06	0.21
Yeild per plant	-0.03	-0.01	-0.05	-0.02	0.20	0.01	0.01	-0.02	-0.01	-0.01	**0.02**	0.40	0.49
Erucic acid	0.05	0.01	0.07	0.01	-0.03	0.01	0.01	0.03	0.01	0.01	-0.02	**-0.80**	-0.64

Table 10c: Contd.
[F_1s in E_2 (Late sown)]

Character	Days to flowering	Days to reproductive phase	No. of primary branches	No. of secondary branches	Height of plant	Length of main fruiting branch	No. of siliquae on main fruiting branch	Days to maturity	Relative water content	Leaf water potential	Yield per plant	Erucic acid	Genotypic correlation with yield (Oil content)
Days to flowering	**0.18**	-0.01	-0.01	0.01	0.01	-0.01	0.02	-0.01	0.11	-0.01	-0.03	-0.22	-0.07
Days to reproductive phase	0.04	**-0.05**	0.02	0.01	-0.03	-0.03	0.03	0.01	0.01	-0.01	0.01	0.13	0.14
No. of primary branches	0.01	0.01	**-0.16**	-0.02	0.01	0.02	0.04	-0.02	-0.01	0.01	0.01	-0.03	-0.13
No. of secondary branches	-0.03	0.01	-0.08	**-0.01**	0.12	-0.01	0.02	0.01	-0.01	0.01	0.07	0.24	0.34
Height of plant	-0.01	-0.01	0.01	0.01	**-0.33**	0.04	0.02	0.01	0.01	-0.01	-0.03	-0.17	-0.46
Length of main fruiting branch	-0.01	0.01	-0.02	0.01	-0.10	**0.14**	0.01	-0.01	0.01	-0.01	0.01	-0.08	-0.04
No. of siliquae on main fruiting branch	0.03	-0.01	-0.06	0.03	-0.06	0.02	**0.10**	-0.01	-0.02	-0.01	-0.02	-0.14	-0.15
Days to maturity	-0.02	-0.01	0.01	-0.01	-0.04	0.01	-0.02	**0.08**	0.01	0.01	0.04	0.21	0.27
Relative water content	0.02	-0.01	0.03	0.01	-0.02	-0.01	-0.02	0.01	**0.01**	0.02	0.01	-0.01	0.04
Leaf water potential	0.01	0.01	0.02	-0.01	0.07	0.01	-0.02	0.01	0.01	**-0.02**	0.02	0.02	0.13
Yeild per plant	-0.04	-0.02	-0.02	-0.01	0.06	0.01	0.01	0.02	0.01	0.01	**0.13**	0.30	0.45
Erucic acid	0.07	0.02	-0.01	-0.02	-0.10	0.02	0.02	-0.03	0.01	0.01	-0.07	**-0.59**	-0.67

Table 10c: Contd.
[F_1s in Pooled (E_1 + E_2)]

Character	Days to flowering	Days to reproductive phase	No. of primary branches	No. of secondary branches	Height of plant	ength of ain ruiting ranch	No. of siliquae on main fruiting branch	Days to maturity	Relative water content	Leaf water potential	Yield er plant	Erucic acid	Genotypic correlation with yield (Oil content)
Days to flowering	**-0.09**	0.02	0.02	0.04	0.04	-0.04	-0.01	-0.03	-0.01	0.01	0.01	-0.14	-0.15
Days to reproductive phase	0.01	**0.17**	0.01	0.01	-0.08	-0.03	0.05	0.06	0.02	0.04	-0.01	0.11	0.29
No. of primary branches	-0.01	0.01	**-0.25**	-0.12	0.04	0.01	-0.03	0.08	0.01	-0.01	-0.02	0.14	-0.13
No. of secondary branches	-0.01	-0.01	-0.16	**-0.03**	0.40	-0.01	-0.02	0.11	0.02	-0.03	-0.04	0.17	0.39
Height of plant	-0.01	0.01	0.03	0.02	**-0.90**	0.06	-0.08	-0.06	-0.01	0.05	0.02	-0.10	-0.97
Length of main fruiting branch	-0.01	-0.02	-0.01	0.01	-023	**0.24**	-0.06	0.09	0.01	-0.02	-0.01	-0.05	-0.06
No. of siliquae on main fruiting branch	0.01	0.04	-0.04	-0.02	-0.29	0.07	**-0.24**	0.14	0.01	0.02	0.01	-0.08	-0.37
Days to maturity	-0.01	0.04	-0.05	-0.01	0.14	0.05	-0.09	**0.38**	-0.01	0-0.05	-0.04	0.17	0.52
Relative water content	0.01	0.04	0.04	-0.01	-0.05	-0.01	-0.01	0.04	**-0.02**	-0.01	-0.01	0.01	0.02
Leaf water potential	0.01	-0.04	0.01	-0.02	0.26	0.02	0.03	0.11	-0.01	**-0.17**	-0.01	0.02	0.29
Yeild per plant	-0.01	0.02	-0.07	-0.01	0.26	0.01	0.02	0.18	-0.01	-0.02	**-0.08**	0.20	0.49
Erucic acid	0.01	-0.05	0.09	0.01	-0.22	0.03	-0.06	-0.16	0.01	0.01	0.04	**-0.39**	-0.68

Table 10d: Direct and indirect effects (Path Coefficient Analysis) at genotypic level for oil yield Vs. other 12 characters in two environments (E_1 and E_2) alongwith their pooled values in 60 F_2s of Indian mustard [F_2s in E_1 (Normal sown)]

Character	Days to flowering	Days to reproductive phase	No. of primary branches	No. of secondary branches	Height of plant	Length of main fruiting branch	No. of siliquae on main fruiting branches	Days to maturity	Relative water content	Leaf water potential	Yield per plant	Erucic acid	Genotypic correlation with yield (Oil content)
Days to flowering	**0.01**	0.01	0.01	-0.01	-0.01	0.01	0.01	-0.01	0.01	0.01	-0.01	-0.35	-0.32
Days to reproductive phase	-0.01	**-0.03**	0.01	-0.03	0.08	0.01	-0.01	0.02`	-0.01	0.01	0.01	0.23	0.29
No. of primary branches	0.01	-0.02	**0.10**	-0.14	-0.06	0.01	0.01	0.03	-0.01	-0.01	-0.01	-0.04	-0.13
No. of secondary branches	0.01	-0.01	0.07	**-0.19**	0.11	-0.01	0.01	0.01	-0.01	0.01	-0.01	0.11	0.10
Height of plant	0.01	0.01	0.01	0.03	**-0.73**	-0.02	-0.02	-0.01	0.02	-0.01	0.01	-0.03	-0.73
Length of main fruiting branch	0.01	-0.01	0.06	0.01	0.02	**0.06**	0.01	0.01	-0.01	0.01	0.02	0.16	0.35
No. of siliquae on main fruiting branch	-0.01	0.02	0.01	-0.01	-0.05	0.03	**0.02**	-0.01	0.01	0.01	-0.01	-0.20	-0.19
Days to maturity	0.01	0.01	-0.03	0.02	-0.05	-0.01	-0.01	**-0.10**	0.01	-0.01	0.01	0.10	-0.35
Relative water content	-0.02	-0.02	0.02	-0.03	0.09	0.01	-0.01	0.02	**-0.04**	0.01	0.02	0.02	0.07
Leaf water potential	0.01	0.01	0.01	0.02	-0.15	-0.01	-0.01	0.01	0.01	**-0.04**	-0.02	0.22	0.36
Yeild per plant	-0.01	0.01	0.02	-0.08	0.12	0.02	0.01	0.01	-0.02	0.01	**-0.01**	0.13	0.21
Erucic acid	0.01	0.01	0.01	0.03	-0.03	0.01	0.01	0.01	0.01	0.01	-0.02	**-0.80**	-0.74

Table 10d: Contd.

[F_2s in E_2 (Late sown)]

Character	Days to lowering	Days to reproductive phase	No. of primary branches	No. of econdary branches	Height of plant	Length of main fruiting branch	No. of siliquae on main fruiting branches	Days to maturity	Relative water content	Leaf water potential	Yield per plant	Erucic acid	Genotypic correlation with yield (Oil content)
Days to flowering	**0.11**	-0.01	-0.02	0.01	-0.08	0.02	0.07	-0.01	-0.02	-0.02	0.01	-0.24	-0.18
Days to reproductive phase	0.01	**-0.09**	0.02	-0.01	0.05	-0.03	-0.03	0.02	0.01	-0.02	0.02	-0.18	-0.23
No. of primary branches	0.03	0.02	**-0.08**	-0.07	-0.08	0.04	0.12	-0.02	-0.01	0.03	-0.01	0.42	-0.40
No. of secondary branches	0.01	-0.01	-0.03	**-0.04**	0.12	0.02	0.05	-0.01	0.02	0.01	-0.03	0.04	0.15
Height of plant	0.02	0.01	-0.02	0.02	**-0.41**	0.05	0.05	0.02	0.01	-0.01	0.02	-0.29	-0.53
Length of main fruiting branch	0.01	0.01	-0.02	-0.01	-0.12	**0.18**	0.07	-0.01	0.02	0.01	-0.01	-0.16	-0.03
No. of siliquae on main fruiting branch	0.03	-0.01	-0.04	-0.02	-0.09	0.05	**0.24**	0.01	-0.02	0.03	-0.01	-0.26	-0.09
Days to maturity	-0.02	-0.01	0.02	0.02	-0.08	-0.01	-0.03	**0.09**	-0.01	-0.02	-0.01	0.26	0.20
Relative water content	-0.02	-0.01	0.01	-0.01	0.01	0.03	-0.03	-0.01	**0.12**	0.01	-0.01	-0.01	0.08
Leaf water potential	-0.01	0.01	0.01	0.01	-0.01	-0.01	-0.05	0.02	-0.01	**-0.14**	0.02	0.20	0.04
Yeild per plant	0.01	0.01	0.01	0.02	0.01	0.03	0.02	0.01	0.01	0.01	**-0.08**	0.11	0.17
Erucic acid	0.04	0.02	-0.05	0.01	-0.17	0.04	0.09	-0.03	0.01	0.04	0.01	**-0.71**	-0.71

Table 10d: Contd.

[F_2s in pooled ($E_1 + E_2$)]

Character	Days to lowering	Days to reproductive phase	No. of primary branches	No. of secondary branches	Height of plant	Length of main fruiting branch	No. of siliquae on main fruiting branches	Days to maturity	Relative water content	Leaf water potential	Yield Per plant	Erucic acid	Genotypic correlation with yield (Oil content)
Days to flowering	0.12	-0.01	-0.10	0.01	-0.12	0.01	-0.02	-0.04	0.02	-0.01	0.01	-0.12	-0.25
Days to reproductive phase	-0.06	**0.05**	0.08	0.02	0.19	0.02	0.03	-0.03	0.01	0.01	0.01	0.12	0.39
No. of primary branches	0.03	0.01	**-0.41**	0.11	-0.02	0.04	-0.03	-0.04	0.01	-0.01	-0.02	-0.13	-0.46
No. of secondary branches	0.02	-0.01	-0.24	**0.18**	0.29	0.01	-0.02	-0.04	-0.02	0.01	0.07	0.03	0.13
Height of plant	0.02	0.01	-0.02	-0.06	**-0.89**	0.05	-0.04	0.01	0.01	0.01	0.05	-0.11	-0.96
Length of main fruiting branch	0.01	-0.01	-0.06	0.01	-0.16	**0.27**	-0.07	0.03	-0.02	0.02	-0.03	-0.08	-0.09
No. of siliquae on main fruiting branch	0.02	0.01	-0.10	0.04	-0.25	0.15	**-0.12**	0.01	0.01	-0.01	-0.02	-0.13	-0.39
Days to maturity	-0.02	0.01	0.10	-0.04	-0.04	0.05	-0.01	**0.18**	-0.01	0.04	-0.01	0.13	0.38
Relative water content	-0.02	-0.01	-0.02	0.03	0.07	0.06	0.02	-0.04	**-0.02**	0.02	-0.01	-0.01	0.08
Leaf water potential	-0.01	0.04	0.03	-002	0.11	-0.02	0.02	0.04	0.01	**0.01**	0.01	0.09	0.31
Yeild per plant	0.01	0.01	0.04	0.08	0.25	0.05	-0.02	0.01	-0.01	0.02	**-0.18**	0.06	0.32
Erucic acid	0.04	0.02	-0.16	-0.01	-0.28	0.06	-0.05	-0.07	-0.01	0.03	0.03	**-0.35**	-0.75

Table 11a: Per Se performance of 23 parents (20 Lines and 3 Testers) in E_1 (Normal sown), E_2 (Late Sown) and their pooled values in Indian mustard

		Days to flowering			Days to reproductive phase		
S.N.	Parent	E_1	E_2	Pooled	E_1	E_2	Pooled
	Lines (Females)						
1.	**RK8601**	37.00	30.66	36.17	86.33	62.00	73.67
2.	**RK8602**	38.00	36.00	37.00	90.67	60.66	77.00
3.	**RK8604**	39.33	36.67	38.00	83.67	60.00	71.33
4.	**RK8605**	41.33	36.67	39.50	89.67	70.66	79.50
5.	**RK8608**	40.00	36.00	38.50	86.00	64.67	75.33
6.	**RK8701**	37.00	32.67	35.33	82.67	52.66	70.50
7.	**RK8702**	32.00	34.66	40.50	80.33	65.67	77.50
8.	**RK8801**	39.00	36.66	37.83	92.00	64.67	78.33
9.	**RK8802**	37.00	33.67	36.00	90.00	54.00	72.33
10.	**RK8803**	39.00	35.67	38.00	90.67	58.67	73.67
11.	**RK8901**	37.00	30.36	35.33	94.00	56.00	75.00
12.	**RK8902**	37.00	30.67	35.33	85.33	50.67	68.00
13.	**RK8903**	40.33	31.66	38.83	87.33	69.00	77.67
14.	**RL9001**	59.00	35.00	37.50	82.00	69.00	75.00
15.	**RK9002**	38.00	29.00	36.50	83.33	68.67	73.50
16.	**RK918506**	36.33	33.00	35.17	87.33	52.73	69.50
17.	**RK911296**	37.67	30.66	36.50	90.67	58.66	76.50
18.	**RK9**	39.67	35.00	37.83	94.33	77.00	85.17
19.	**RK14**	39.00	35.67	36.83	91.33	67.00	78.67
20.	**KRV 47**	38.00	30.66	37.67	91.00	52.66	75.17
	Testers (Males)						
21.	**Mathura Rai**	35.00	30.66	34.17	75.00	66.67	74.83
22.	**Laha 101**	37.33	34.00	36.17	82.67	57.72	69.67
23.	**Vaibhav**	39.67	35.67	38.17	86.67	60.72	73.17

Table 11a: Contd.

		Number of primary branches			Number of secondary branches		
S.N.	**Parent**	**E_1**	**E_2**	**Pooled**	**E_1**	**E_2**	**Pooled**
	Lines (Females)						
1.	**RK8601**	7.67	6.37	7.07	6.00	9.00	12.50
2.	**RK8602**	5.00	4.17	4.58	50.67	8.67	12.17
3.	**RK8604**	6.33	5.43	5.88	21.33	11.67	16.50
4.	**RK8605**	5.00	5.17	5.08	41.67	8.33	11.50
5.	**RK8608**	7.33	6.80	7.07	22.67	12.00	17.33
6.	**RK8701**	6.67	5.67	6.17	16.67	9.33	13.00
7.	**RK8702**	6.67	7.00	6.83	22.00	12.00	17.00
8.	**RK8801**	11.33	8.60	9.97	25.67	14.33	20.00
9.	**RK8802**	5.67	5.63	5.65	16.67	9.33	13.00
10.	**RK8803**	7.00	7.57	7.28	19.67	10.67	15.17
11.	**RK8901**	7.33	3.80	5.57	16.33	9.00	12.67
12.	**RK8902**	7.00	7.57	7.28	23.00	12..67	17.83
13.	**RK8903**	6.33	8.43	7.38	13.00	7.00	10.00
14.	**RL9001**	5.00	5.83	5.42	15.00	8.33	11.67
15.	**RK9002**	6.00	5.53	5.77	18.67	8.00	11.33
16.	**RK918506**	6.00	9.20	7.60	13.33	7.33	10.33
17.	**RK911296**	8.00	8.60	8.30	25.33	14.00	19.67
18.	**RK9**	6.67	5.67	6.17	19.00	10.33	14.67
19.	**RK14**	6.00	5.53	5.77	12.00	6.67	9.33
20.	**KRV 47**	6.33	4.77	5.55	13.33	7.33	10.33
	Testers (Males)						
21.	**Mathura Rai**	6.33	4.77	5.55	15.00	8.33	11.67
22.	**Laha 101**	5.67	6.30	5.98	13.33	7.33	10.33
23.	**Vaibhav**	6.60	4.87	5.57	15.20	8.67	11.93

Table 11a: Contd.

		Height of plant			Length of main fruiting branch		
S.N.	Parent	E_1	E_2	Pooled	E_1	E_2	Pooled
	Lines (Females)						
1.	**RK8601**	180.33	123.67	152.00	49.67	33.67	41.67
2.	**RK8602**	178.33	145.66	169.83	55.67	44.67	50.17
3.	**RK8604**	155.00	146.00	149.50	64.00	48.67	55.84
4.	**RK8605**	154.00	106.00	128.50	68.33	53.00	60.67
5.	**RK8608**	140.67	114.00	126.84	60.00	34.00	47.00
6.	**RK8701**	151.33	121.66	146.33	76.33	30.00	52.67
7.	**RK8702**	115.33	142.30	127.83	66.33	40.66	55.33
8.	**RK8801**	171.00	110.30	136.67	73.67	46.00	59.83
9.	**RK8802**	166.67	165.00	158.34	67.00	41.00	54.00
10.	**RK8803**	144.00	113.00	131.50	62.33	44.67	53.50
11.	**RK8901**	146.33	116.67	130.50	65.67	39.67	52.67
12.	**RK8902**	152.67	115.67	131.67	62.67	39.00	50.83
13.	**RK8903**	147.00	121.66	132.84	63.67	31.33	47.50
14.	**RL9001**	143.67	140.00	140.84	73.00	26.00	49.50
15.	**RK9002**	156.00	100.66	135.67	80.00	45.00	62.50
16.	**RK918506**	151.00	140.00	146.00	77.00	55.66	68.17
17.	**RK911296**	149.67	116.67	133.17	75.00	46.67	60.84
18.	**RK9**	160.33	146.67	142.50	77.67	46.00	61.84
19.	**RK14**	142.00	169.67	154.84	78.67	53.00	65.84
20.	**KRV 47**	148.00	97.66	130.17	76.67	50.64	66.00
	Testers (Males)						
21.	**Mathura Rai**	115.00	144.69	109.67	30.00	26.00	28.00
22.	**Laha 101**	185.00	176.40	178.75	45.00	42.00	43.00
23.	**Vaibhav**	145.00	145.67	142.84	60.00	38.00	39.50

Table 11a: Contd.

S.N.	Parent	Number of silliquae on main fruiting branch			Day of maturity		
		E_1	E_2	Pooled	E_1	E_2	Pooled
	Lines (Females)						
1.	**RK8601**	54.00	26.00	40.00	123.33	100.33	111.84
2.	**RK8602**	56.67	29.00	42.83	128.67	103.33	116.00
3.	**RK8604**	44.00	33.67	38.83	123.00	114.67	121.33
4.	**RK8605**	44.67	36.67	40.67	136.00	111.00	121.00
5.	**RK8608**	40.33	32.33	36.33	126.00	105.67	115.83
6.	**RK8701**	44.67	26.33	35.50	119.67	106.00	117.83
7.	**RK8702**	38.33	26.33	32.33	113.00	108.00	120.00
8.	**RK8801**	45.67	30.67	38.17	131.33	105.00	118.16
9.	**RK8802**	48.67	27.00	37.83	127.33	112.67	120.33
10.	**RK8803**	51.67	28.00	39.83	130.83	117.00	113.67
11.	**RK8901**	54.33	27.33	40.83	131.00	113.67	122.33
12.	**RK8902**	52.33	32.67	42.50	122.33	108.33	115.33
13.	**RK8903**	39.33	43.33	41.33	137.66	109.00	118.50
14.	**RL9001**	45.33	32.00	38.67	141.00	108.00	114.50
15.	**RK9002**	65.33	28.33	46.83	121.33	102.67	112.00
16.	**RK918506**	67.33	35.00	51.17	123.66	109.67	116.67
17.	**RK911296**	65.00	39.67	52.33	128.34	101.66	115.00
18.	**RK9**	60.67	45.00	52.83	134.00	116.00	125.00
19.	**RK14**	65.67	23.67	39.67	130.33	116.67	118.50
20.	**KRV 47**	64.00	20.00	42.00	129.00	118.66	113.84
	Testers (Males)						
21.	**Mathura Rai**	58.00	18.00	33.00	110.00	101.00	111.00
22.	**Laha 101**	51.67	25.00	38.33	137.00	115.67	117.84
23.	**Vaibhav**	46.63	26.33	36.33	128.00	100.34	113.34

Table 11a: Contd.

S.N.	Parent	Relative water content			Leaf water potential		
		E_1	E_2	Pooled	E_1	E_2	Pooled
	Lines (Females)						
1.	**RK8601**	91.20	46.53	68.87	10.40	13.20	11.80
2.	**RK8602**	80.93	41.30	61.12	10.10	12.80	11.50
3.	**RK8604**	79.83	40.73	60.28	12.20	15.40	13.80
4.	**RK8605**	91.40	46.63	69.02	8.80	11.20	10.00
5.	**RK8608**	78.67	40.17	59.42	11.40	14.40	12.90
6.	**RK8701**	86.23	44.00	65.12	12.80	16.20	14.50
7.	**RK8702**	82.17	41.93	62.05	11.80	14.90	13.40
8.	**RK8801**	92.87	47.40	70.13	13.50	17.00	15.20
9.	**RK8802**	81.27	41.47	61.37	17.90	22.70	20.30
10.	**RK8803**	83.13	42.47	62.80	13.30	16.90	15.10
11.	**RK8901**	82.50	42.13	62.32	11.20	14.20	12.70
12.	**RK8902**	92.30	47.10	69.70	11.70	14.50	13.20
13.	**RK8903**	76.73	39.17	57.95	11.60	14.70	13.10
14.	**RL9001**	81.63	41.63	61.63	13.10	16.60	14.90
15.	**RK9002**	93.07	47.50	70.28	11.10	14.10	12.60
16.	**RK918506**	78.83	40.23	59.53	10.20	12.90	11.50
17.	**RK911296**	82.57	42.17	62.37	29.80	12.40	11.10
18.	**RK9**	91.60	46.73	69.17	12.20	15.50	13.90
19.	**RK14**	93.00	47.47	70.23	15.00	18.90	17.00
20.	**KRV 47**	83.23	42.47	62.85	14.20	17.90	16.10
	Testers (Males)						
21.	**Mathura Rai**	88.37	45.13	66.75	13.60	17.30	15.50
22.	**Laha 101**	76.60	39.07	57.83	12.70	16.00	14.30
23.	**Vaibhav**	88.90	45.37	67.13	14.00	15.10	14.50

Table 11a: Contd.

S.N.	Parent	Yield per plant			Oil content		
		E1	E2	Pooled	E1	E2	Pooled
	Lines (Females)						
1.	**RK8601**	38.00	21.67	29.83	28.28	23.17	25.72
2.	**RK8602**	30.33	17.33	23.83	29.67	23.81	26.74
3.	**RK8604**	39.00	22.33	30.67	32.36	25.06	28.71
4.	**RK8605**	26.67	15.00	20.83	32.47	25.12	28.80
5.	**RK8608**	28.00	16.00	22.00	34.01	25.83	29.92
6.	**RK8701**	32.00	18.33	25.17	32.78	25.26	29.02
7.	**RK8702**	38.00	21.67	29.83	36.93	27.19	32.06
8.	**RK8801**	36.67	20.67	28.67	30.51	24.20	27.36
9.	**RK8802**	24.33	13.67	19.00	31.01	24.43	27.72
10.	**RK8803**	31.00	17.67	24.33	34.78	26.19	30.48
11.	**RK8901**	35.33	20.00	27.67	33.36	25.53	29.44
12.	**RK8902**	30.67	34.33	32.50	32.62	25.19	28.90
13.	**RK8903**	29.00	16.33	22.67	33.28	25.49	29.39
14.	**RL9001**	27.00	15.33	21.17	33.66	25.67	29.67
15.	**RK9002**	23.67	13.33	19.83	32.24	25.01	28.63
16.	**RK918506**	25.33	14.33	19.83	32.82	25.28	29.05
17.	**RK911296**	35.33	31.33	33.33	32.97	25.35	29.16
18.	**RK9**	26.33	15.00	20.67	31.74	24.79	28.26
19.	**RK14**	28.00	16.00	22.00	33.86	25.76	29.81
20.	**KRV 47**	25.67	14.67	20.17	33.16	25.44	29.30
	Testers (Males)						
21.	**Mathura Rai**	36.00	20.67	28.33	33.32	15.51	24.41
22.	**Laha 101**	33.67	19.33	26.50	31.05	17.79	24.42
23.	**Vaibhav**	33.67	19.40	28.53	33.97	25.81	29.89

Table 11a: Contd.

		Erucic Acid		
S.N.	**Parent**	**E_1**	**E_2**	**Pooled**
	Lines (Females)			
1.	**RK8601**	50.22	49.52	50.57
2.	**RK8602**	50.53	49.39	51.72
3.	**RK8604**	52.39	51.87	52.13
4.	**RK8605**	53.00	49.30	51.20
5.	**RK8608**	49.60	45.87	49.45
6.	**RK8701**	54.25	49.08	51.82
7.	**RK8702**	49.60	50.37	49.34
8.	**RK8801**	49.60	48.70	51.20
9.	**RK8802**	49.60	48.70	51.20
10.	**RK8803**	50.84	48.80	51.82
11.	**RK8901**	52.39	49.08	50.89
12.	**RK8902**	49.60	46.70	50.58
13.	**RK8903**	52.70	50.00	52.13
14.	**RL9001**	50.84	50.56	50.60
15.	**RK9002**	49.91	49.60	48.74
16.	**RK918506**	48.98	48.53	48.10
17.	**RK911296**	49.91	48.22	49.34
18.	**RK9**	49.60	48.53	49.65
19.	**RK14**	50.53	50.70	50.27
20.	**KRV 47**	49.29	50.39	50.89
	Testers (Males)			
21.	**Mathura Rai**	49.60	49.09	49.60
22.	**Laha 101**	49.91	53.81	50.22
23.	**Vaibhav**	50.53	50.53	49.65

Table 11b: Per se performance of 60 F_1s in E_1 (Normal sown), E_2 (Late sown) and their pooled values for 13 characters in Indian mustard

S.N.	Crosses	Days to flowering			Days to reproductive phase		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	40.67	36.37	36.17	86.67	71.00	78.84
2.	RK8602 x Mathura Rai	36.33	33.33	35.33	91.33	74.00	82.67
3.	RK8604 x Mathura Rai	33.67	31.33	33.00	93.67	76.00	84.84
4.	RK8605 x Mathura Rai	34.00	31.67	33.33	89.67	73.00	81.34
5.	RK8608 x Mathura Rai	33.67	31.67	33.17	89.33	73.00	81.17
6.	RK8701 x Mathura Rai	35.33	31.67	34.50	82.67	68.67	75.67
7.	RK8702 x Mathura Rai	34.00	31.33	33.17	83.33	69.00	81.17
8.	RK8801 x Mathura Rai	33.67	31.67	33.17	85.67	70.67	83.17
9.	RK8802 x Mathura Rai	34.67	32.33	34.00	88.67	72.67	80.67
10.	RK8803 x Mathura Rai	35.67	32.67	34.67	83.67	69.00	76.34
11.	RK8901 x Mathura Rai	32.33	30.33	31.83	83.33	69.00	76.17
12.	RK8902 x Mathura Rai	34.33	13.67	33.50	89.00	72.67	80.83
13.	RK8903 x Mathura Rai	36.00	33.00	35.00	86.00	70.67	78.34
14.	RL9001 x Mathura Rai	40.33	36.33	38.83	96.67	77.67	87.17
15.	RK9002 x Mathura Rai	33.33	31.33	32.83	93.00	75.33	84.17
16.	RK918506 x Mathura Rai	37.67	34.33	36.50	86.67	77.33	82.00
17.	RK911296 x Mathura Rai	34.33	31.67	33.51	87.33	77.67	82.50
18.	RK9 x Mathura Rai	38.00	34.33	36.67	92.33	75.00	83.67
19.	RK14 x Mathura Rai	36.33	33.33	35.33	88.67	72.33	80.50
20.	KRV 47 x Mathura Rai	35.67	32.67	34.67	92.33	75.00	83.67
21.	RK8601 x Laha 101	35.67	33.00	34.83	89.33	73.00	81.17
22.	RK8602 x Laha 101	34.00	31.67	33.33	89.67	73.00	81.34
23	RK8604 x Laha 101	38.67	35.00	37.33	86.33	70.67	78.50
24	RK8605 x Laha 101	32.67	31.00	32.33	96.00	77.67	86.84
25	RK8608 x Laha 101	34.67	32.00	33.83	92.33	74.67	83.50
26.	RK8701 x Laha 101	38.33	35.00	37.17	94.33	76.33	85.33
27.	RK8702 x Laha 101	37.33	34.00	36.17	90.67	73.67	82.17
28.	RK8801 x Laha 101	38.33	35.00	37.17	83.67	79.00	76.34
29.	RK8802 x Laha 101	35.67	32.67	34.67	88.33	72.33	80.33
30.	RK8803 x Laha 101	35.00	35.00	34.17	86.67	77.33	82.00
31.	RK8901 x Laha 101	39.33	39.33	37.83	89.67	73.00	81.34
32.	RK8902 x Laha 101	37.00	34.00	36.00	83.33	79.00	76.17
33.	RK8903 x Laha 101	37.33	34.00	36.17	95.33	77.00	86.17
34.	RL9001 x Laha 101	43.33	36.33	38.83	91.67	74.33	83.00
35.	RK9002 x Laha 101	36.67	33.67	35.67	86.00	70.62	78.31
36.	RK918506 x Laha 101	36.67	34.00	35.83	96.67	78.00	87.34
37.	RK911296 x Laha 101	37.67	34.33	36.50	94.33	76.33	85.33
38.	RK9 x Laha 101	35.67	32.67	34.67	91.33	74.00	82.67
39.	RK14 x Laha 101	33.33	31.33	32.83	89.33	73.00	81.17
40.	KRV 47 x Laha 101	35.33	32.33	34.33	91.67	74.33	83.00
41.	RK8601 xVaibhav	38.33	34.67	37.00	95.00	76.67	89.84
42.	RK8602 xVaibhav	39.33	35.67	38.00	97.33	78.00	87.67
43.	RK8604 xVaibhav	39.33	35.67	38.00	86.67	71.33	79.00
44	RK8605 xVaibhav	38.67	35.00	37.33	90.67	73.67	82.17
45.	RK8608 xVaibhav	35.00	35.67	38.33	89.00	73.00	81.00
46.	RK8701 xVaibhav	41.00	36.67	39.33	93.67	76.00	84.84
47.	RK8702 xVaibhav	34.00	31.33	33.17	88.67	71.33	79.00
48.	RK8801 xVaibhav	39.00	35.33	37.67	84.00	69.33	76.67
49.	RK8802 xVaibhav	37.00	33.67	35.83	88.67	72.67	80.84
50.	RK8803 xVaibhav	41.67	37.33	40.00	93.67	76.00	84.84
51.	RK8901 xVaibhav	41.33	37.00	39.67	96.33	77.67	87.00
52.	RK8902 xVaibhav	37.00	33.67	35.67	91.33	74.00	82.67
53.	RK8903 xVaibhav	35.67	32.67	34.67	92.67	75.00	83.84
54.	RL9001 xVaibhav	34.67	32.33	34.00	96.00	77.33	86.67
55.	RK9002 xVaibhav	36.00	33.00	35.00	96.00	77.33	86.67
56.	RK918506 xVaibhav	34.67	32.33	34.00	93.67	75.67	84.67
57.	RK911296 xVaibhav	41.33	41.67	39.50	87.33	71.67	79.50
58.	RK9 x Vaibhav	39.33	39.33	37.83	84.00	69.33	76.67
59.	RK14 xVaibhav	31.67	33.33	33.00	91.67	74.67	83.17
60.	KRV 47 xVaibhav	33.33	33.33	32.83	94.33	76.33	85.33

Table 11b: Contd.

S.N.	Crosses	Number of primary branches			Number of secondary branches		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	8.00	5.60	6.80	30.00	16.00	23.00
2.	RK8602 x Mathura Rai	8.00	5.60	6.80	29.67	16.00	22.83
3.	RK8604 x Mathura Rai	10.00	7.00	8.50	25.00	13.67	90.33
4.	RK8605 x Mathura Rai	7.33	5.13	6.23	20.67	11.33	60.00
5.	RK8608 x Mathura Rai	11.67	8.17	9.92	36.00	19.67	27.83
6.	RK8701 x Mathura Rai	7.67	5.37	6.52	21.33	11.33	60.33
7.	RK8702 x Mathura Rai	6.33	4.43	5.38	18.00	10.00	14.00
8.	RK8801 x Mathura Rai	10.33	7.23	8.78	26.00	14.33	20.17
9.	RK8802 x Mathura Rai	11.00	7.70	9.35	21.00	11.33	16.17
10.	RK8803 x Mathura Rai	7.00	4.90	5.95	21.33	12.00	16.67
11.	RK8901 x Mathura Rai	9.00	6.30	7.65	22.67	12.33	17.50
12.	RK8902 x Mathura Rai	6.00	4.20	5.10	23.67	13.00	18.33
13.	RK8903 x Mathura Rai	10.00	7.00	8.50	24.67	13.67	19.17
14.	RL9001 x Mathura Rai	10.33	7.23	8.78	21.00	11.33	16.17
15.	RK9002 x Mathura Rai	5.00	3.50	4.25	18.00	10.00	14.00
16.	RK918506 x Mathura Rai	8.00	5.60	6.80	18.67	10.00	14.33
17.	RK911296 x Mathura Rai	7.33	5.13	6.23	19.00	10.33	14.67
18.	RK9 x Mathura Rai	9.00	6.30	7.65	31.00	16.67	23.83
19.	RK14 x Mathura Rai	7.33	5.13	6.23	26.00	14.33	20.50
20.	KRV 47 x Mathura Rai	7.33	5.13	6.23	25.00	13.67	19.33
21.	RK8601 x Laha 101	8.00	5.60	6.80	22.33	12.00	17.17
22.	RK8602 x Laha 101	9.00	6.30	7.65	21.00	11.33	16.17
23	RK8604 x Laha 101	6.33	4.33	5.33	15.33	8.33	11.83
24	RK8605 x Laha 101	6.00	4.20	5.10	15.00	8.33	11.67
25	RK8608 x Laha 101	11.67	8.17	9.92	36.00	19.67	27.83
26.	RK8701 x Laha 101	5.00	3.50	4.25	18.67	10.33	14.50
27.	RK8702 x Laha 101	7.67	5.37	6.52	23.00	12.33	17.67
28.	RK8801 x Laha 101	10.33	7.20	8.77	38.00	21.00	29.50
29.	RK8802 x Laha 101	7.00	4.90	5.95	17.33	9.33	13.33
30.	RK8803 x Laha 101	5.33	3.73	4.53	14.33	8.00	11.17
31.	RK8901 x Laha 101	7.00	4.90	5.95	25.00	13.67	19.33
32.	RK8902 x Laha 101	9.00	5.30	7.15	25.67	14.33	20.00
33.	RK8903 x Laha 101	7.00	4.90	5.95	19.00	10.33	14.67
34.	RL9001 x Laha 101	8.00	5.60	6.80	18.67	10.00	14.33
35.	RK9002 x Laha 101	9.00	6.30	7.65	21.00	11.33	16.17
36.	RK918506 x Laha 101	6.00	4.20	5.10	18.67	10.00	14.33
37.	RK911296 x Laha 101	6.00	4.20	5.10	22.00	12.00	17.00
38.	RK9 x Laha 101	10.00	7.00	8.50	28.00	15.00	21.50
39.	RK14 x Laha 101	11.00	7.70	9.35	32.67	17.33	25.00
40.	KRV 47 x Laha 101	11.00	6.77	8.88	25.00	13.67	19.30
41.	RK8601 xVaibhav	12.33	8.63	10.48	37.67	20.67	29.17
42.	RK8602 xVaibhav	8.33	5.83	7.08	18.00	10.00	14.00
43.	RK8604 xVaibhav	10.00	7.00	8.50	32.33	17.33	24.83
44	RK8605 xVaibhav	9.00	6.30	7.65	23.33	12.67	18.00
45.	RK8608 xVaibhav	10.00	7.00	8.50	27.33	15.00	21.17
46.	RK8701 xVaibhav	10.00	7.00	8.50	19.67	10.67	15.17
47.	RK8702 xVaibhav	11.67	8.17	9.92	20.00	11.00	15.50
48.	RK8801 xVaibhav	9.00	6.30	7.65	20.67	11.00	15.83
49.	RK8802 xVaibhav	9.00	6.33	7.67	26.00	14.33	20.17
50.	RK8803 xVaibhav	9.00	8.63	7.65	18.00	10.00	14.00
51.	RK8901 xVaibhav	6.00	5.83	5.22	15.00	8.33	11.67
52.	RK8902 xVaibhav	8.00	7.00	6.80	22.67	12.00	17.33
53.	RK8903 xVaibhav	6.33	6.30	5.38	14.67	8.00	11.33
54.	RL9001 xVaibhav	7.00	7.00	5.95	13.67	7.67	10.67
55.	RK9002 xVaibhav	8.00	7.00	6.80	14.67	8.33	11.50
56.	RK918506 xVaibhav	12.00	8.17	10.20	17.67	9.67	13.67
57.	RK911296 xVaibhav	10.00	6.30	8.50	21.67	11.67	16.67
58.	RK9 x Vaibhav	8.67	6.30	7.37	16.33	9.00	12.67
59.	RK14 xVaibhav	10.00	7.00	8.50	26.00	14.00	20.00
60.	KRV 47 xVaibhav	10.33	7.23	7.78	19.33	10.33	14.83

Table 11b : Contd.

S.N.	Crosses	Height of plant			Length of main fruiting branch		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	138.34	112.67	125.67	74.67	42.33	58.50
2.	RK8602 x Mathura Rai	135.67	110.33	123.00	76.33	43.00	59.67
3.	RK8604 x Mathura Rai	136.00	110.67	123.33	60.33	36.00	48.17
4.	RK8605 x Mathura Rai	161.33	129.33	145.33	71.00	40.67	55.83
5.	RK8608 x Mathura Rai	155.67	125.33	140.50	61.67	38.00	51.50
6.	RK8701 x Mathura Rai	158.00	127.00	142.52	75.67	43.00	59.33
7.	RK8702 x Mathura Rai	157.33	126.67	142.00	77.00	43.67	60.33
8.	RK8801 x Mathura Rai	161.67	137.33	154.00	75.00	42.33	58.67
9.	RK8802 x Mathura Rai	167.33	141.33	159.33	71.67	41.00	56.33
10.	RK8803 x Mathura Rai	150.33	121.67	136.00	60.00	36.00	48.00
11.	RK8901 x Mathura Rai	165.33	147.33	166.33	182.33	46.00	64.17
12.	RK8902 x Mathura Rai	144.00	117.33	130.67	86.00	38.00	51.50
13.	RK8903 x Mathura Rai	162.67	130.67	146.67	88.33	46.67	65.33
14.	RL9001 x Mathura Rai	164.00	143.67	173.83	76.67	43.33	60.00
15.	RK9002 x Mathura Rai	160.67	141.00	160.83	78.33	44.00	61.17
16.	RK918506 x Mathura Rai	167.67	134.33	151.00	66.67	38.67	52.67
17.	RK911296 x Mathura Rai	167.67	141.67	159.67	88.33	48.67	64.50
18.	RK9 x Mathura Rai	161.00	144.33	162.67	78.33	44.00	61.17
19.	RK14 x Mathura Rai	160.67	136.67	153.67	73.67	42.00	57.83
20.	KRV 47 x Mathura Rai	165.67	140.67	151.67	85.00	47.00	63.50
21.	RK8601 x Laha 101	138.67	112.67	125.67	68.67	39.67	54.17
22.	RK8602 x Laha 101	163.33	138.67	156.00	80.00	47.33	63.67
23	RK8604 x Laha 101	162.67	123.00	162.83	69.00	39.67	54.33
24	RK8605 x Laha 101	163.33	138.33	95.83	80.33	47.67	64.00
25	RK8608 x Laha 101	166.33	170.67	193.50	80.67	48.67	64.67
26.	RK8701 x Laha 101	164.00	139.00	156.50	76.67	43.33	60.00
27.	RK8702 x Laha 101	151.67	122.67	137.17	62.00	36.67	59.33
28.	RK8801 x Laha 101	165.33	147.33	166.33	66.00	38.67	52.33
29.	RK8802 x Laha 101	167.00	134.00	150.50	180.67	46.33	65.00
30.	RK8803 x Laha 101	166.33	133.33	149.83	75.67	43.00	59.33
31.	RK8901 x Laha 101	169.67	136.00	152.83	72.67	41.67	57.17
32.	RK8902 x Laha 101	157.00	126.33	141.67	80.33	46.33	64.83
33.	RK8903 x Laha 101	161.33	137.00	154.17	74.67	42.67	58.67
34.	RL9001 x Laha 101	150.00	121.33	135.67	64.00	37.67	50.83
35.	RK9002 x Laha 101	193.67	153.33	173.50	87.67	45.33	63.50
36.	RK918506 x Laha 101	125.00	102.67	113.83	53.67	33.00	43.33
37.	RK911296 x Laha 101	144.67	117.33	131.00	63.33	37.67	50.50
38.	RK9 x Laha 101	165.00	147.00	166.00	66.67	39.00	52.83
39.	RK14 x Laha 101	133.33	109.00	121.17	75.33	43.00	59.50
40.	KRV 47 x Laha 101	162.33	152.33	173.33	77.00	43.33	60.17
41.	RK8601 xVaibhav	162.67	130.67	146.67	71.33	41.00	46.17
42.	RK8602 xVaibhav	132.67	108.33	120.50	56.67	34.33	45.50
43.	RK8604 xVaibhav	145.67	120.33	134.67	63.67	37.67	50.67
44	RK8605 xVaibhav	166.33	148.00	167.17	61.33	36.33	48.83
45.	RK8608 xVaibhav	164.66	167.00	189.17	66.00	38.67	52.33
46.	RK8701 xVaibhav	167.33	134.00	150.67	72.67	41.67	57.17
47.	RK8702 xVaibhav	174.00	141.67	159.50	80.67	57.00	78.83
48.	RK8801 xVaibhav	163.00	175.67	199.33	66.00	38.33	52.17
49.	RK8802 xVaibhav	164.33	169.00	191.67	63.00	37.33	50.17
50.	RK8803 xVaibhav	148.67	120.33	135.50	78.67	44.00	61.33
51.	RK8901 xVaibhav	169.67	165.67	187.67	70.00	38.00	51.50
52.	RK8902 xVaibhav	163.33	138.67	156.00	75.67	42.67	59.17
53.	RK8903 xVaibhav	161.33	137.00	154.17	66.33	38.67	52.50
54.	RL9001 xVaibhav	163.34	170.67	193.67	67.00	39.00	53.00
55.	RK9002 xVaibhav	165.33	170.00	192.67	64.33	37.67	51.00
56.	RK918506 xVaibhav	165.00	179.00	201.00	44.00	28.67	36.33
57.	RK911296 xVaibhav	162.33	160.00	181.17	80.33	46.67	65.50
58.	RK9 x Vaibhav	151.22	122.00	136.67	70.67	40.33	55.50
59.	RK14 xVaibhav	164.00	169.00	191.50	73.67	42.00	57.83
60.	KRV 47 xVaibhav	161.33	152.00	171.67	71.33	41.00	56.17

Table 11b: Contd.

S.N.	Crosses	Number of Siliquae on main fruiting branch			Days to maturity		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	54.00	28.67	41.33	127.34	107.67	118.34
2.	RK8602 x Mathura Rai	53.67	28.67	41.17	122.96	107.33	118.34
3.	RK8604 x Mathura Rai	48.00	25.33	36.67	127.34	107.33	118.67
4.	RK8605 x Mathura Rai	53.00	28.33	40.67	123.67	105.34	114.67
5.	RK8608 x Mathura Rai	52.33	28.00	40.17	123.00	114.67	114.34
6.	RK8701 x Mathura Rai	40.33	21.33	30.83	118.00	110.35	110.17
7.	RK8702 x Mathura Rai	40.33	21.33	30.83	117.33	110.33	114.34
8.	RK8801 x Mathura Rai	44.67	23.67	34.17	119.32	112.34	116.34
9.	RK8802 x Mathura Rai	43.67	23.00	33.33	123.34	105.34	114.67
10.	RK8803 x Mathura Rai	32.00	17.00	24.50	119.34	101.67	111.01
11.	RK8901 x Mathura Rai	45.33	24.00	34.67	115.66	99.33	108.00
12.	RK8902 x Mathura Rai	41.33	22.00	31.67	123.33	104.34	114.34
13.	RK8903 x Mathura Rai	42.00	22.00	32.00	122.00	103.67	113.34
14.	RL9001 x Mathura Rai	66.67	35.67	51.17	137.00	114.00	126.00
15.	RK9002 x Mathura Rai	52.67	28.00	40.33	126.33	106.66	117.00
16.	RK918506 x Mathura Rai	45.67	24.00	34.83	124.33	111.66	118.00
17.	RK911296 x Mathura Rai	46.67	24.67	35.67	121.99	109.34	116.01
18.	RK9 x Mathura Rai	56.33	30.50	43.17	130.33	109.33	120.34
19.	RK14 x Mathura Rai	54.33	29.00	41.67	125.00	105.66	115.83
20.	KRV 47 x Mathura Rai	47.00	25.00	36.00	128.00	107.67	118.34
21.	RK8601 x Laha 101	42.00	22.33	32.17	125.00	106.00	116.00
22.	RK8602 x Laha 101	52.00	27.67	39.83	123.67	104.67	114.67
23	RK8604 x Laha 101	44.67	24.33	34.50	127.00	105.67	115.83
24	RK8605 x Laha 101	50.33	27.00	38.67	124.67	108.67	119.17
25	RK8608 x Laha 101	66.33	35.33	50.83	127.00	106.67	117.33
26.	RK8701 x Laha 101	41.00	21.67	31.33	132.66	111.33	122.50
27.	RK8702 x Laha 101	36.67	19.67	28.17	128.00	107.67	118.34
28.	RK8801 x Laha 101	54.67	29.00	41.83	122.00	114.00	113.51
29.	RK8802 x Laha 101	55.67	29.33	42.50	124.00	105.00	114.66
30.	RK8803 x Laha 101	47.33	25.00	36.17	121.67	109.66	116.17
31.	RK8901 x Laha 101	43.33	23.00	33.17	129.00	108.33	119.17
32.	RK8902 x Laha 101	52.67	28.00	40.33	120.00	113.00	112.17
33.	RK8903 x Laha 101	70.00	37.00	53.50	132.66	111.00	112.34
34.	RL9001 x Laha 101	41.00	21.67	31.33	134.99	110.66	121.83
35.	RK9002 x Laha 101	71.67	38.00	54.83	122.67	104.29	113.98
36.	RK918506 x Laha 101	62.00	33.00	47.50	133.34	112.00	123.17
37.	RK911296 x Laha 101	54.00	28.67	41.33	132.00	110.66	121.83
38.	RK9 x Laha 101	56.33	30.00	43.17	127.00	106.67	117.34
39.	RK14 x Laha 101	66.00	35.00	50.50	122.66	104.33	114.00
40.	KRV 47 x Laha 101	52.33	28.00	40.17	127.00	106.66	117.33
41.	RK8601 xVaibhav	62.67	33.33	48.00	133.33	111.34	126.34
42.	RK8602 xVaibhav	44.33	23.33	33.83	136.66	113.67	125.67
43.	RK8604 xVaibhav	54.00	28.67	41.33	126.00	107.00	117.00
44	RK8605 xVaibhav	55.67	29.67	42.67	129.34	108.67	119.50
45.	RK8608 xVaibhav	53.33	28.33	40.83	129.00	108.67	119.33
46.	RK8701 xVaibhav	49.33	26.33	37.83	138.50	112.66	124.17
47.	RK8702 xVaibhav	58.00	31.00	44.50	120.67	102.66	112.17
48.	RK8801 xVaibhav	52.67	28.00	40.33	123.00	104.66	114.34
49.	RK8802 xVaibhav	37.67	19.67	28.67	126.00	106.34	116.67
50.	RK8803 xVaibhav	57.67	30.67	44.17	135.34	113.33	124.84
51.	RK8901 xVaibhav	38.00	20.00	29.00	137.66	114.67	126.67
52.	RK8902 xVaibhav	45.33	24.00	34.67	128.00	107.67	118.34
53.	RK8903 xVaibhav	61.33	32.33	46.83	128.34	107.67	118.51
54.	RL9001 xVaibhav	70.33	37.33	53.83	130.67	109.66	120.67
55.	RK9002 xVaibhav	64.67	34.33	49.50	124.00	110.33	121.67
56.	RK918506 xVaibhav	45.33	23.67	34.50	128.24	108.00	118.67
57.	RK911296 xVaibhav	54.67	29.00	41.83	128.66	108.34	119.00
58.	RK9 x Vaibhav	37.67	20.00	28.83	123.33	104.66	114.50
59.	RK14 xVaibhav	51.00	27.33	39.17	125.34	106.00	116.17
60.	KRV 47 xVaibhav	46.67	24.67	35.67	127.66	107.66	118.16

Table 11b: Contd.

S.N.	Crosses	Relative water content			Leaf water potential		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	92.37	47.13	69.75	15.10	19.00	17.00
2.	RK8602 x Mathura Rai	76.43	39.00	57.72	11.10	14.10	12.60
3.	RK8604 x Mathura Rai	88.03	44.93	66.48	11.10	14.00	12.60
4.	RK8605 x Mathura Rai	85.77	43.77	64.77	10.80	13.60	12.20
5.	RK8608 x Mathura Rai	88.40	45.10	66.75	13.30	16.90	15.10
6.	RK8701 x Mathura Rai	83.03	42.40	62.72	14.90	18.80	16.90
7.	RK8702 x Mathura Rai	84.00	42.87	63.43	11.40	14.40	12.90
8.	RK8801 x Mathura Rai	88.97	45.40	67.18	12.00	15.20	13.60
9.	RK8802 x Mathura Rai	87.53	44.67	66.10	15.40	19.40	17.40
10.	RK8803 x Mathura Rai	77.20	39.37	58.28	11.50	14.50	13.10
11.	RK8901 x Mathura Rai	83.97	42.87	63.42	15.10	19.10	17.10
12.	RK8902 x Mathura Rai	78.60	40.13	59.37	13.10	16.50	14.80
13.	RK8903 x Mathura Rai	76.30	38.93	57.62	13.50	17.10	13.30
14.	RL9001 x Mathura Rai	91.90	46.87	69.38	10.20	12.90	11.60
15.	RK9002 x Mathura Rai	87.77	44.80	66.28	14.90	18.90	16.90
16.	RK918506 x Mathura Rai	88.93	45.40	67.17	16.70	21.10	18.90
17.	RK911296 x Mathura Rai	76.50	39.03	57.77	14.50	18.30	16.40
18.	RK9 x Mathura Rai	95.33	48.67	72.00	12.60	16.00	14.30
19.	RK14 x Mathura Rai	92.87	47.40	70.13	12.40	15.70	14.10
20.	KRV 47 x Mathura Rai	93.00	47.47	70.23	11.20	14.20	12.70
21.	RK8601 x Laha 101	89.03	45.47	67.25	14.30	20.70	17.50
22.	RK8602 x Laha 101	85.23	43.50	64.37	07.90	10.00	09.00
23	RK8604 x Laha 101	90.20	46.03	68.12	09.10	11.60	10.40
24	RK8605 x Laha 101	87.07	44.43	65.75	11.60	14.60	13.10
25	RK8608 x Laha 101	77.03	39.30	58.17	12.20	15.50	13.80
26.	RK8701 x Laha 101	89.40	45.63	67.52	13.40	17.00	15.20
27.	RK8702 x Laha 101	76.17	38.87	57.52	11.50	14.60	13.10
28.	RK8801 x Laha 101	84.53	43.17	63.85	12.50	15.80	14.20
29.	RK8802 x Laha 101	79.30	40.47	59.88	10.50	13.30	11.90
30.	RK8803 x Laha 101	93.43	4767	70.55	10.60	13.50	12.00
31.	RK8901 x Laha 101	95.37	48.67	72.02	16.70	21.20	18.90
32.	RK8902 x Laha 101	80.03	4083	60.43	18.10	22.90	20.50
33.	RK8903 x Laha 101	92.70	47.30	70.00	16.50	20.90	18.70
34.	RL9001 x Laha 101	97.13	49.57	73.35	11.40	14.40	12.90
35.	RK9002 x Laha 101	87.67	44.77	66.22	11.60	14.70	15.20
36.	RK918506 x Laha 101	91.30	46.57	68.93	10.20	13.00	11.60
37.	RK911296 x Laha 101	84.70	43.23	63.97	15.20	19.30	17.30
38.	RK9 x Laha 101	87.80	44.83	66.32	13.40	16.90	15.10
39.	RK14 x Laha 101	75.30	38.43	56.87	14.40	18.20	16.30
40.	KRV 47 x Laha 101	82.20	41.93	62.07	14.10	17.80	16.00
41.	RK8601 xVaibhav	87.47	44.63	66.05	15.10	17.70	16.40
42.	RK8602 xVaibhav	81.57	41.67	61.62	13.40	16.90	15.20
43.	RK8604 xVaibhav	78.50	40.03	59.27	12.70	16.00	14.30
44	RK8605 xVaibhav	94.27	48.10	71.18	12.50	15.80	14.10
45.	RK8608 xVaibhav	87.33	44.53	65.93	11.70	14.80	13.20
46.	RK8701 xVaibhav	87.03	44.40	65.72	11.40	14.50	12.90
47.	RK8702 xVaibhav	78.90	40.27	59.58	11.70	14.90	13.30
48.	RK8801 xVaibhav	75.90	38.73	57.32	12.60	15.90	14.30
49.	RK8802 xVaibhav	82.80	42.10	62.30	10.80	13.60	12.20
50.	RK8803 xVaibhav	75.27	38.40	56.83	10.60	13.50	12.00
51.	RK8901 xVaibhav	85.63	43.70	64.67	10.40	13.10	11.7o
52.	RK8902 xVaibhav	73.93	37.73	55.83	10.20	12.90	11.50
53.	RK8903 xVaibhav	85.90	43.83	64.87	11.70	14.90	13.30
54.	RL9001 xVaibhav	82.27	42.00	62.13	13.30	16.90	15.10
55.	RK9002 xVaibhav	77.27	39.40	58.33	06.90	08.80	07.90
56.	RK918506 xVaibhav	81.97	41.83	61.90	10.20	13.00	11.60
57.	RK911296 xVaibhav	87.53	44.67	66.10	13.50	17.10	15.30
58.	RK9 x Vaibhav	92.03	46.97	69.50	14.80	18.70	16.70
59.	RK14 xVaibhav	94.57	48.27	71.42	10.60	13.40	12.00
60.	KRV 47 xVaibhav	88.20	45.00	66.60	06.60	08.40	07.50

Tablse 11b:Contd.

S.N.	Crosses	Yield per plant E1	Yield per plant E2	Yield per plant Pooled	Oil content E1	Oil content E2	Oil content Pooled
1.	RK8601 x Mathura Rai	83.00	47.00	65.00	44.13	30.54	37.33
2.	RK8602 x Mathura Rai	86.67	49.33	68.00	44.53	30.73	37.67
3.	RK8604 x Mathura Rai	45.67	25.67	35.67	44.49	30.71	37.60
4.	RK8605 x Mathura Rai	47.00	27.00	37.00	41.07	29.12	35.09
5.	RK8608 x Mathura Rai	102.67	57.67	80.17	41.83	29.47	35.65
6.	RK8701 x Mathura Rai	40.00	23.00	31.50	41.52	29.33	35.42
7.	RK8702 x Mathura Rai	42.33	24.00	33.17	41.61	29.37	35.49
8.	RK8801 x Mathura Rai	88.67	50.33	69.50	39.67	28.47	34.07
9.	RK8802 x Mathura Rai	51.00	29.00	40.00	38.91	28.11	33.51
10.	RK8803 x Mathura Rai	59.67	34.00	46.83	42.55	29.81	36.18
11.	RK8901 x Mathura Rai	46.33	26.33	36.33	37.83	27.61	32.72
12.	RK8902 x Mathura Rai	47.00	27.00	37.00	43.41	30.20	36.81
13.	RK8903 x Mathura Rai	46.00	26.00	36.00	40.89	29.03	34.96
14.	RL9001 x Mathura Rai	71.67	26.67	49.17	36.66	27.07	31.86
15.	RK9002 x Mathura Rai	58.33	33.00	45.67	38.79	27.90	33.35
16.	RK918506 x Mathura Rai	62.00	35.00	48.50	40.21	28.72	34.47
17.	RK911296 x Mathura Rai	67.33	38.00	52.67	38.86	28.09	33.48
18.	RK9 x Mathura Rai	71.67	40.67	56.17	38.41	27.88	33.15
19.	RK14 x Mathura Rai	79.67	45.33	62.50	39.81	28.53	34.17
20.	KRV 47 x Mathura Rai	80.67	45.67	63.17	39.13	28.22	33.67
21.	RK8601 x Laha 101	84.33	48.00	66.17	44.12	30.54	37.33
22.	RK8602 x Laha 101	56.33	32.00	44.17	39.45	27.70	33.57
23	RK8604 x Laha 101	52.67	30.00	41.33	36.84	27.15	32.00
24	RK8605 x Laha 101	81.67	46.33	64.00	39.45	28.36	33.91
25	RK8608 x Laha 101	47.00	26.67	36.83	33.64	24.66	29.15
26.	RK8701 x Laha 101	55.33	31.33	43.33	39.36	28.32	33.84
27.	RK8702 x Laha 101	45.33	25.67	35.00	42.37	29.72	36.05
28.	RK8801 x Laha 101	28.00	15.67	31.83	37.83	27.61	32.72
29.	RK8802 x Laha 101	60.67	34.67	47.67	40.30	28.70	34.53
30.	RK8803 x Laha 101	43.00	24.33	33.67	40.39	28.80	34.60
31.	RK8901 x Laha 101	65.67	37.33	51.50	39.94	28.59	34.27
32.	RK8902 x Laha 101	43.33	24.67	34.00	41.65	29.39	35.52
33.	RK8903 x Laha 101	50.33	28.33	39.33	39.72	28.49	34.10
34.	RL9001 x Laha 101	51.33	29.00	40.17	42.60	29.83	36.21
35.	RK9002 x Laha 101	41.33	23.33	32.33	36.70	27.09	31.89
36.	RK918506 x Laha 101	40.67	23.33	32.00	45.97	31.40	38.69
37.	RK911296 x Laha 101	25.67	14.33	20.00	43.32	30.16	36.74
38.	RK9 x Laha 101	45.33	25.67	35.50	37.87	27.73	32.75
39.	RK14 x Laha 101	62.33	35.33	48.83	44.85	27.54	36.19
40.	KRV 47 x Laha 101	115.67	64.33	90.00	36.88	27.17	32.02
41.	RK8601 xVaibhav	71.67	40.67	56.17	40.89	29.03	34.96
42.	RK8602 xVaibhav	55.67	31.67	43.67	44.94	30.91	37.93
43.	RK8604 xVaibhav	92.67	52.33	72.50	42.73	29.89	36.31
44	RK8605 xVaibhav	46.00	26.00	36.00	37.69	27.55	32.62
45.	RK8608 xVaibhav	77.67	44.00	60.83	34.32	25.97	30.14
46.	RK8701 xVaibhav	52.33	29.67	41.00	40.26	28.74	34.50
47.	RK8702 xVaibhav	54.67	31.00	42.83	38.91	28.11	33.51
48.	RK8801 xVaibhav	45.33	25.67	35.50	32.74	25.24	28.99
49.	RK8802 xVaibhav	47.67	27.00	37.73	33.91	25.79	29.85
50.	RK8803 xVaibhav	47.00	26.33	36.67	42.78	29.91	36.35
51.	RK8901 xVaibhav	40.33	23.00	31.67	34.54	26.08	30.31
52.	RK8902 xVaibhav	41.33	23.33	32.33	39.45	28.36	33.90
53.	RK8903 xVaibhav	46.67	26.67	36.67	39.72	28.49	34.10
54.	RL9001 xVaibhav	44.33	25.33	34.83	33.60	25.64	29.62
55.	RK9002 xVaibhav	48.33	27.33	37.83	33.78	25.72	29.75
56.	RK918506 xVaibhav	34.67	19.67	27.17	32.47	25.11	28.79
57.	RK911296 xVaibhav	46.00	26.33	36.17	35.53	26.54	31.07
58.	RK9 x Vaibhav	39.00	22.33	30.17	42.42	29.75	36.08
59.	RK14 xVaibhav	34.33	19.67	27.00	33.96	25.81	29.88
60.	KRV 47 xVaibhav	46.33	26.33	36.33	37.02	27.23	32.12

Table 11b: Contd.

S.N.	Crosses	Erucic acid		
		E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	50.53	49.91	50.22
2.	RK8602 x Mathura Rai	50.84	50.22	50.53
3.	RK8604 x Mathura Rai	51.46	49.91	50.84
4.	RK8605 x Mathura Rai	51.46	50.22	50.84
5.	RK8608 x Mathura Rai	51.15	50.22	50.53
6.	RK8701 x Mathura Rai	50.53	50.22	50.53
7.	RK8702 x Mathura Rai	50.81	49.22	50.22
8.	RK8801 x Mathura Rai	50.81	49.22	50.53
9.	RK8802 x Mathura Rai	49.14	48.53	50.84
10.	RK8803 x Mathura Rai	51.15	48.53	50.53
11.	RK8901 x Mathura Rai	51.15	49.22	50.53
12.	RK8902 x Mathura Rai	50.53	50.22	50.84
13.	RK8903 x Mathura Rai	50.53	50.22	50.84
14.	RL9001 x Mathura Rai	50.53	49.53	50.53
15.	RK9002 x Mathura Rai	50.53	48.53	50.53
16.	RK918506 x Mathura Rai	50.53	49.22	50.22
17.	RK911296 x Mathura Rai	50.53	49.91	50.22
18.	RK9 x Mathura Rai	50.22	49.91	49.91
19.	RK14 x Mathura Rai	50.22	50.22	50.22
20.	KRV 47 x Mathura Rai	51.15	50.53	50.84
21.	RK8601 x Laha 101	50.88	49.53	50.83
22.	RK8602 x Laha 101	50.84	47.53	50.84
23	RK8604 x Laha 101	50.84	47.84	50.84
24	RK8605 x Laha 101	50.53	48.84	50.84
25	RK8608 x Laha 101	50.46	49.53	50.53
26.	RK8701 x Laha 101	50.53	50.53	50.53
27.	RK8702 x Laha 101	50.53	50.53	50.53
28.	RK8801 x Laha 101	50.84	49.22	50.53
29.	RK8802 x Laha 101	50.84	48.53	50.84
30.	RK8803 x Laha 101	50.84	49.22*	50.53
31.	RK8901 x Laha 101	50.84	48.22	50.53
32.	RK8902 x Laha 101	50.22	47.84	50.53
33.	RK8903 x Laha 101	50.22	48.84	50.53
34.	RL9001 x Laha 101	50.53	49.84	50.84
35.	RK9002 x Laha 101	50.53	49.53	50.53
36.	RK918506 x Laha 101	50.84	48.53	50.84
37.	RK911296 x Laha 101	50.84	47.15	51.15
38.	RK9 x Laha 101	50.53	47.84	50.84
39.	RK14 x Laha 101	50.22	49.53	50.53
40.	KRV 47 x Laha 101	50.22	48.53	50.53
41.	RK8601 xVaibhav	50.22	48.53	50.53
42.	RK8602 xVaibhav	50.53	49.22	50.53
43.	RK8604 xVaibhav	50.53	49.22	50.53
44	RK8605 xVaibhav	50.53	48.53	50.53
45.	RK8608 xVaibhav	50.53	49.84	50.84
46.	RK8701 xVaibhav	50.53	48.84	50.84
47.	RK8702 xVaibhav	50.22	48.84	50.53
48.	RK8801 xVaibhav	50.53	49.53	50.53
49.	RK8802 xVaibhav	50.84	47.53	50.84
50.	RK8803 xVaibhav	50.53	49.84	50.84
51.	RK8901 xVaibhav	50.53	48.84	50.84
52.	RK8902 xVaibhav	50.53	48.84	50.84
53.	RK8903 xVaibhav	50.84	49.15	50.84
54.	RL9001 xVaibhav	50.84	48.15	50.84
55.	RK9002 xVaibhav	50.84	49.15	51.15
56.	RK918506 xVaibhav	50.84	49.74	50.84
57.	RK911296 xVaibhav	50.53	48.15	50.84
58.	RK9 x Vaibhav	50.53	48.15	50.84
59.	RK14 xVaibhav	50.53	48.15	50.84
60.	KRV 47 xVaibhav	50.53	49.84	50.84

Table 11c: Per se performance of 60 F_2s in E_1 (Normal sown), E_2 (Late sown) and their pooled values for 13 characters in Indian mustard

S.N.	Crosses	Days to flowering			Days to reproductive phase		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	34.00	31.67	32.33	90.00	63.00	76.50
2.	RK8602 x Mathura Rai	39.33	35.67	38.00	91.00	64.33	77.67
3.	RK8604 x Mathura Rai	32.67	31.00	32.33	91.67	64.33	78.00
4.	RK8605 x Mathura Rai	31.67	34.00	31.33	92.67	65.00	78.83
5.	RK8608 x Mathura Rai	35.67	33.00	34.83	94.67	66.33	80.50
6.	RK8701 x Mathura Rai	33.67	31.67	33.17	94.67	66.33	80.50
7.	RK8702 x Mathura Rai	31.33	30.00	31.17	94.67	66.67	80.67
8.	RK8801 x Mathura Rai	41.00	36.67	39.33	88.00	62.00	75.00
9.	RK8802 x Mathura Rai	39.33	33.00	36.67	84.00	59.33	71.67
10.	RK8803 x Mathura Rai	34.00	31.67	33.33	88.33	62.33	75.33
11.	RK8901 x Mathura Rai	37.33	34.33	36.33	84.00	59.33	71.67
12.	RK8902 x Mathura Rai	33.67	31.33	33.00	90.33	65.67	76.83
13.	RK8903 x Mathura Rai	34.67	32.33	34.00	93.67	67.67	79.67
14.	RL9001 x Mathura Rai	39.67	35.33	38.00	96.33	65.67	82.00
15.	RK9002 x Mathura Rai	37.33	34.00	36.17	94.00	66.33	79.83
16.	RK918506 x Mathura Rai	33.67	31.67	33.17	94.33	59.00	80.33
17.	RK911296 x Mathura Rai	34.67	32.00	33.83	83.67	61.00	71.33
18.	RK9 x Mathura Rai	39.67	36.00	38.33	86.33	62.00	73.67
19.	RK14 x Mathura Rai	34.67	32.33	34.00	89.00	62.67	75.83
20.	KRV 47 x Mathura Rai	40.33	36.00	38.67	92.33	65.00	78.67
21.	RK8601 x Laha 101	32.67	30.67	32.17	96.00	67.33	81.67
22.	RK8602 x Laha 101	35.00	32.33	34.17	96.33	67.67	82.00
23	RK8604 x Laha 101	39.00	35.33	37.67	86.67	61.00	73.83
24	RK8605 x Laha 101	35.33	32.33	34.33	84.00	59.33	71.67
25	RK8608 x Laha 101	35.33	32.67	34.50	89.67	53.00	76.33
26.	RK8701 x Laha 101	37.00	34.00	36.00	86.33	51.00	73.67
27.	RK8702 x Laha 101	36.00	33.00	35.00	84.00	49.33	71.67
28.	RK8801 x Laha 101	37.00	33.00	35.50	93.67	65.67	79.67
29.	RK8802 x Laha 101	39.00	35.67	42.83	92.33	65.00	78.67
30.	RK8803 x Laha 101	35.67	33.00	34.83	88.67	62.67	75.67
31.	RK8901 x Laha 101	38.33	33.00	37.17	93.00	65.33	79.17
32.	RK8902 x Laha 101	41.67	37.00	39.83	95.00	67.00	81.00
33.	RK8903 x Laha 101	34.67	32.33	34.00	86.00	60.67	73.33
34.	RL9001 x Laha 101	35.67	32.33	34.50	89.33	63.00	76.17
35.	RK9002 x Laha 101	40.33	36.33	38.83	94.00	66.00	80.00
36.	RK918506 x Laha 101	35.33	32.67	34.50	90.67	63.67	77.17
37.	RK911296 x Laha 101	39.00	35.33	37.67	85.67	60.67	73.17
38.	RK9 x Laha 101	35.67	26.67	34.67	88.33	62.33	75.33
39.	RK14 x Laha 101	38.00	34.67	36.83	88.67	62.67	75.67
40.	KRV 47 x Laha 101	40.00	35.67	38.33	94.00	66.00	80.00
41.	RK8601 xVaibhav	35.67	33.00	34.83	96.33	67.33	81.83
42.	RK8602 xVaibhav	34.67	32.00	33.83	91.33	64.00	77.67
43.	RK8604 xVaibhav	39.33	36.67	38.50	84.00	49.33	71.67
44	RK8605 xVaibhav	31.00	36.33	39.17	88.33	62.33	75.33
45.	RK8608 xVaibhav	34.67	32.00	33.83	94.00	66.00	80.00
46.	RK8701 xVaibhav	34.33	32.00	33.67	91.33	64.00	77.67
47.	RK8702 xVaibhav	39.00	35.33	37.67	89.67	67.33	78.50
48.	RK8801 xVaibhav	36.33	33.33	35.33	92.67	65.00	78.83
49.	RK8802 xVaibhav	35.00	32.33	33.17	85.33	67.00	81.17
50.	RK8803 xVaibhav	34.67	30.67	32.17	94.00	66.00	80.00
51.	RK8901 xVaibhav	35.67	35.67	34.83	91.00	64.00	96.50
52.	RK8902 xVaibhav	34.00	34.00	33.33	88.67	62.67	75.67
53.	RK8903 xVaibhav	35.67	35.67	34.63	85.67	60.67	73.17
54.	RL9001 xVaibhav	36.33	36.33	35.50	91.67	64.33	78.00
55.	RK9002 xVaibhav	35.67	35.67	34.83	96.00	67.33	81.67
56.	RK918506 xVaibhav	34.67	34.67	34.00	94.00	66.00	80.00
57.	RK911296 xVaibhav	33.33	33.33	37.83	87.33	61.33	74.33
58.	RK9 x Vaibhav	36.67	36.67	35.50	89.00	62.67	75.83
59.	RK14 xVaibhav	40.67	40.67	39.00	91.67	64.33	78.00
60.	KRV 47 xVaibhav	36.67	36.67	35.07	90.33	63.00	77.00

Table 11c: Contd.

S.N.	Crosses	Number of primary branches			Number of Secondary branches		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	5.00	3.50	4.25	17.33	9.33	13.33
2.	RK8602 x Mathura Rai	6.33	4.43	5.38	15.00	8.33	11.67
3.	RK8604 x Mathura Rai	5.00	3.50	4.25	15.33	8.33	11.83
4.	RK8605 x Mathura Rai	7.00	4.90	5.95	20.00	10.67	15.33
5.	RK8608 x Mathura Rai	6.00	4.20	5.10	16.33	9.00	12.67
6.	RK8701 x Mathura Rai	6.00	4.20	5.10	14.00	7.67	10.83
7.	RK8702 x Mathura Rai	5.00	3.50	4.25	17.33	9.33	13.33
8.	RK8801 x Mathura Rai	6.33	2.80	4.57	16.33	9.00	12.67
9.	RK8802 x Mathura Rai	7.00	4.90	5.95	10.67	5.67	8.17
10.	RK8803 x Mathura Rai	7.33	5.13	6.23	15.67	8.67	12.17
11.	RK8901 x Mathura Rai	8.33	5.83	7.08	21.33	11.67	16.50
12.	RK8902 x Mathura Rai	5.33	3.73	4.53	14.67	8.00	11.33
13.	RK8903 x Mathura Rai	7.00	4.90	5.95	18.67	10.00	14.33
14.	RL9001 x Mathura Rai	8.67	6.07	7.37	25.33	14.00	19.67
15.	RK9002 x Mathura Rai	7.00	3.27	5.13	25.67	14.00	19.83
16.	RK918506 x Mathura Rai	7.00	4.90	5.95	21.00	11.33	16.17
17.	RK911296 x Mathura Rai	5.33	3.73	4.53	19.33	10.33	14.83
18.	RK9 x Mathura Rai	7.00	4.90	5.95	18.00	10.00	14.00
19.	RK14 x Mathura Rai	7.00	4.90	5.95	18.33	10.00	14.17
20.	KRV 47 x Mathura Rai	5.00	3.50	4.25	14.67	8.00	11.33
21.	RK8601 x Laha 101	7.00	4.90	5.95	23.00	12.33	17.67
22.	RK8602 x Laha 101	7.33	5.13	6.23	25.67	14.00	19.83
23	RK8604 x Laha 101	6.33	4.43	5.38	17.33	9.33	13.33
24	RK8605 x Laha 101	6.00	4.20	5.10	20.00	11.67	16.83
25	RK8608 x Laha 101	6.33	4.43	5.38	23.00	12.33	17.67
26.	RK8701 x Laha 101	6.33	4.43	5.38	18.00	10.00	14.00
27.	RK8702 x Laha 101	5.00	3.50	4.25	18.00	10.00	14.00
28.	RK8801 x Laha 101	7.00	4.90	5.95	19.33	10.67	15.00
29.	RK8802 x Laha 101	5.33	3.73	4.53	16.33	9.00	12.67
30.	RK8803 x Laha 101	7.00	4.90	5.95	18.33	9.67	14.00
31.	RK8901 x Laha 101	8.00	5.60	6.80	18.00	9.67	13.83
32.	RK8902 x Laha 101	5.00	3.50	4.25	13.67	7.33	10.50
33.	RK8903 x Laha 101	6.67	4.67	5.67	16.33	9.00	12.67
34.	RL9001 x Laha 101	7.00	4.90	5.95	18.33	10.00	14.17
35.	RK9002 x Laha 101	7.67	5.30	6.48	20.00	10.67	15.33
36.	RK918506 x Laha 101	8.00	5.60	6.80	24.00	13.00	18.50
37.	RK911296 x Laha 101	7.33	5.13	6.23	21.67	11.67	16.67
38.	RK9 x Laha 101	6.00	3.73	4.87	16.67	9.33	13.00
39.	RK14 x Laha 101	5.33	4.43	4.88	14.33	7.67	11.00
40.	KRV 47 x Laha 101	6.33	4.43	5.38	20.33	11.00	15.67
41.	RK8601 xVaibhav	5.00	3.50	4.25	14.00	7.67	10.83
42.	RK8602 xVaibhav	5.33	3.73	4.53	13.33	7.67	10.50
43.	RK8604 xVaibhav	7.00	4.90	5.95	15.33	8.33	11.83
44	RK8605 xVaibhav	5.00	3.50	4.25	15.33	8.67	12.00
45.	RK8608 xVaibhav	5.33	3.73	4.53	12.33	7.00	9.67
46.	RK8701 xVaibhav	5.67	3.97	4.83	13.67	7.67	10.67
47.	RK8702 xVaibhav	5.33	3.73	4.53	12.67	7.00	9.83
48.	RK8801 xVaibhav	5.67	3.97	4.82	13.67	7.67	10.67
49.	RK8802 xVaibhav	7.00	4.90	5.95	16.33	9.00	12.67
50.	RK8803 xVaibhav	4.33	3.03	3.68	15.67	8.67	12.17
51.	RK8901 xVaibhav	7.67	5.37	6.52	15.00	8.33	11.67
52.	RK8902 xVaibhav	8.00	5.60	6.80	13.33	7.33	10.33
53.	RK8903 xVaibhav	5.00	3.50	4.25	15.00	8.00	11.50
54.	RL9001 xVaibhav	5.67	3.97	4.82	15.67	8.33	12.00
55.	RK9002 xVaibhav	8.00	5.60	6.80	18.67	10.33	14.50
56.	RK918506 xVaibhav	6.00	4.20	5.10	16.67	9.00	12.83
57.	RK911296 xVaibhav	6.67	4.67	5.67	15.00	8.33	11.67
58.	RK9 x Vaibhav	6.67	4.67	5.67	18.33	10.00	14.17
59.	RK14 xVaibhav	5.33	3.73	4.53	15.00	8.33	11.67
60.	KRV 47 xVaibhav	6.00	4.20	5.19	14.00	8.00	11.00

Table 11c: Contd.

S.N.	Crosses	Height of plant			Length of main fruiting branch		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	147.00	119.33	133.16	72.00	46.00	59.00
2.	RK8602 x Mathura Rai	160.33	144.00	192.16	47.67	34.67	41.17
3.	RK8604 x Mathura Rai	154.00	124.33	139.16	51.67	36.67	44.17
4.	RK8605 x Mathura Rai	166.67	141.00	153.83	54.33	36.00	46.17
5.	RK8608 x Mathura Rai	267.00	151.00	159.00	51.33	56.33	43.83
6.	RK8701 x Mathura Rai	165.33	157.00	161.16	56.00	38.67	47.33
7.	RK8702 x Mathura Rai	167.67	134.67	151.17	56.63	38.67	47.50
8.	RK8801 x Mathura Rai	169.00	142.67	155.83	57.67	39.33	48.50
9.	RK8802 x Mathura Rai	168.00	149.67	158.83	60.33	40.33	50.33
10.	RK8803 x Mathura Rai	161.33	137.00	149.16	62.33	41.33	51.67
11.	RK8901 x Mathura Rai	158.00	127.00	142.50	62.00	41.33	51.67
12.	RK8902 x Mathura Rai	162.67	127.70	144.83	65.67	43.00	54.67
13.	RK8903 x Mathura Rai	169.67	160.67	165.17	60.00	40.00	50.00
14.	RL9001 x Mathura Rai	165.33	136.00	150.66	68.00	35.00	41.50
15.	RK9002 x Mathura Rai	160.67	147.67	154.17	65.67	43.00	54.33
16.	RK918506 x Mathura Rai	169.00	144.00	156.50	61.67	41.00	51.33
17.	RK911296 x Mathura Rai	154.00	150.33	152.16	64.67	42.33	53.50
18.	RK9 x Mathura Rai	172.00	124.00	148.00	78.00	48.33	53.17
19.	RK14 x Mathura Rai	169.00	140.00	153.33	49.33	35.67	42.50
20.	KRV 47 x Mathura Rai	138.67	135.67	137.17	46.00	46.00	59.33
21.	RK8601 x Laha 101	161.00	119.67	140.33	67.67	52.67	70.17
22.	RK8602 x Laha 101	162.33	144.33	153.33	64.67	42.67	53.67
23	RK8604 x Laha 101	176.67	130.33	153.50	54.00	37.67	45.83
24	RK8605 x Laha 101	169.67	141.33	155.50	56.67	39.00	47.83
25	RK8608 x Laha 101	164.00	150.24	157.16	65.67	43.00	54.33
26.	RK8701 x Laha 101	167.67	131.67	149.67	54.67	38.00	46.33
27.	RK8702 x Laha 101	162.00	134.33	148.16	55.00	42.67	53.83
28.	RK8801 x Laha 101	168.67	145.00	156.83	56.00	38.34	47.33
29.	RK8802 x Laha 101	154.67	142.67	148.67	38.67	26.33	27.50
30.	RK8803 x Laha 101	166.67	124.67	145.67	54.33	42.33	38.33
31.	RK8901 x Laha 101	153.67	148.33	151.00	78.67	48.67	63.67
32.	RK8902 x Laha 101	168.67	123.67	146.17	79.00	41.33	85.17
33.	RK8903 x Laha 101	166.67	157.33	162.00	73.33	46.33	59.83
34.	RL9001 x Laha 101	160.67	148.67	154.67	65.00	42.67	53.83
35.	RK9002 x Laha 101	165.33	167.33	166.33	52.67	37.33	45.00
36.	RK918506 x Laha 101	148.33	140.00	144.16	62.00	41.33	51.67
37.	RK911296 x Laha 101	164.67	139.67	152.17	35.33	38.33	46.83
38.	RK9 x Laha 101	165.00	132.67	148.83	68.00	44.00	56.00
39.	RK14 x Laha 101	166.67	133.67	150.17	56.67	39.00	47.83
40.	KRV 47 x Laha 101	168.00	157.00	162.50	59.67	40.00	49.83
41.	RK8601 xVaibhav	140.67	114.33	127.50	47.33	34.67	41.00
42.	RK8602 xVaibhav	170.33	136.33	153.33	56.33	38.67	47.50
43.	RK8604 xVaibhav	162.67	160.00	161.33	30.33	27.33	28.83
44	RK8605 xVaibhav	165.67	162.67	164.17	70.67	45.00	57.83
45.	RK8608 xVaibhav	164.33	132.00	148.16	63.00	41.67	52.33
46.	RK8701 xVaibhav	166.00	152.33	159.16	56.00	34.00	40.00
47.	RK8702 xVaibhav	166.00	133.00	149.50	48.00	34.67	41.33
48.	RK8801 xVaibhav	151.67	122.33	137.00	57.33	39.00	48.17
49.	RK8802 xVaibhav	164.33	132.00	148.16	55.33	39.00	48.17
50.	RK8803 xVaibhav	175.33	140.00	157.66	45.67	33.67	39.67
51.	RK8901 xVaibhav	162.00	159.67	160.83	75.00	47.00	61.00
52.	RK8902 xVaibhav	164.00	154.00	159.00	38.00	30.33	34.17
53.	RK8903 xVaibhav	169.00	150.33	159.66	48.00	34.67	41.33
54.	RL9001 xVaibhav	167.33	156.33	161.83	66.00	42.67	54.33
55.	RK9002 xVaibhav	142.00	115.00	128.50	56.67	43.33	55.00
56.	RK918506 xVaibhav	167.33	134.00	150.66	55.67	38.67	47.17
57.	RK911296 xVaibhav	168.33	157.00	162.66	64.00	42.00	53.00
58.	RK9 x Vaibhav	165.00	132.00	148.50	50.67	36.33	43.60
59.	RK14 xVaibhav	163.00	118.33	140.66	31.33	27.27	29.50
60.	KRV 47 xVaibhav	163.33	161.00	162.16	51.67	36.67	44.17

Table 11c Contd.

S.N.	Crosses	Number of siliquae on main fruiting branch			Days to maturity		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	57.67	30.67	44.17	123.00	99.67	111.83
2.	RK8602 x Mathura Rai	52.33	28.00	40.17	130.33	105.00	117.67
3.	RK8604 x Mathura Rai	47.33	25.00	36.17	123.67	100.33	112.33
4.	RK8605 x Mathura Rai	47.33	25.33	36.33	124.34	100.00	112.16
5.	RK8608 x Mathura Rai	56.67	30.00	43.33	130.00	104.33	117.33
6.	RK8701 x Mathura Rai	47.67	25.00	36.33	128.34	103.00	115.67
7.	RK8702 x Mathura Rai	46.67	24.67	35.67	126.00	101.67	113.84
8.	RK8801 x Mathura Rai	48.00	25.67	36.83	129.00	103.67	116.33
9.	RK8802 x Mathura Rai	42.67	22.67	32.67	123.37	97.33	110.34
10.	RK8803 x Mathura Rai	53.33	28.33	40.83	112.33	99.00	110.66
11.	RK8901 x Mathura Rai	57.00	30.00	43.50	121.33	98.66	110.00
12.	RK8902 x Mathura Rai	45.67	24.00	34.83	124.00	102.00	111.83
13.	RK8903 x Mathura Rai	45.67	24.33	35.00	128.34	105.00	115.67
14.	RL9001 x Mathura Rai	46.00	24.00	35.00	136.00	106.00	122.00
15.	RK9002 x Mathura Rai	45.33	24.00	34.67	131.33	105.33	118.00
16.	RK918506 x Mathura Rai	46.67	24.67	35.67	128.00	95.67	115.50
17.	RK911296 x Mathura Rai	50.33	27.00	38.67	118.34	101.33	107.16
18.	RK9 x Mathura Rai	47.33	25.00	36.17	126.00	103.00	114.00
19.	RK14 x Mathura Rai	38.67	20.00	29.33	123.67	100.00	111.83
20.	KRV 47 x Mathura Rai	45.33	24.00	34.67	132.66	106.00	119.34
21.	RK8601 x Laha 101	50.33	27.00	38.67	128.67	103.00	115.84
22.	RK8602 x Laha 101	52.67	28.00	40.33	131.33	105.00	118.17
23	RK8604 x Laha 101	46.00	24.00	35.00	125.67	101.33	113.50
24	RK8605 x Laha 101	42.67	22.33	32.50	119.33	99.66	108.00
25	RK8608 x Laha 101	45.00	23.67	34.33	125.00	100.67	112.83
26.	RK8701 x Laha 101	45.00	24.00	34.50	123.33	108.00	111.67
27.	RK8702 x Laha 101	69.67	37.00	53.33	120.00	100.66	108.67
28.	RK8801 x Laha 101	38.33	20.33	29.33	130.67	103.67	117.17
29.	RK8802 x Laha 101	53.00	28.00	40.50	131.33	105.67	118.50
30.	RK8803 x Laha 101	43.00	23.00	33.00	124.34	100.67	112.50
31.	RK8901 x Laha 101	71.00	38.00	54.50	131.33	105.33	118.34
32.	RK8902 x Laha 101	62.67	33.33	48.00	136.67	109.00	122.83
33.	RK8903 x Laha 101	58.00	31.00	44.50	120.67	98.00	109.33
34.	RL9001 x Laha 101	65.33	35.00	50.17	125.00	100.33	112.67
35.	RK9002 x Laha 101	55.67	29.67	42.67	134.33	107.33	120.83
36.	RK918506 x Laha 101	57.00	30.00	43.50	126.00	101.34	113.67
37.	RK911296 x Laha 101	55.33	29.33	42.33	124.67	124.67	112.84
38.	RK9 x Laha 101	51.33	27.33	39.33	124.00	94.00	112.00
39.	RK14 x Laha 101	53.00	28.33	40.67	124.67	102.34	114.70
40.	KRV 47 x Laha 101	55.67	29.33	42.50	134.00	106.67	120.33
41.	RK8601 xVaibhav	35.33	18.67	27.00	132.00	105.33	118.66
42.	RK8602 xVaibhav	46.67	24.67	35.67	126.00	101.00	113.50
43.	RK8604 xVaibhav	36.67	19.67	28.17	123.33	101.00	112.17
44	RK8605 xVaibhav	45.33	24.00	34.67	129.33	103.66	116.50
45.	RK8608 xVaibhav	43.33	22.67	33.00	128.67	103.00	115.83
46.	RK8701 xVaibhav	38.67	20.33	29.50	125.66	101.00	113.34
47.	RK8702 xVaibhav	40.33	21.33	30.83	128.67	107.66	118.17
48.	RK8801 xVaibhav	46.67	24.67	35.67	129.00	103.33	116.16
49.	RK8802 xVaibhav	48.67	26.00	37.33	130.33	104.33	117.34
50.	RK8803 xVaibhav	50.33	26.67	38.50	128.67	101.67	114.17
51.	RK8901 xVaibhav	50.67	26.67	38.67	126.67	102.00	133.33
52.	RK8902 xVaibhav	44.67	23.67	34.17	122.67	102.67	111.00
53.	RK8903 xVaibhav	46.33	24.33	35.33	121.34	106.34	109.80
54.	RL9001 xVaibhav	51.67	27.33	39.50	128.00	103.00	115.50
55.	RK9002 xVaibhav	39.00	21.00	30.00	131.67	105.33	118.50
56.	RK918506 xVaibhav	45.33	24.00	34.67	131.67	103.33	116.00
57.	RK911296 xVaibhav	39.67	21.33	30.50	120.66	100.99	109.16
58.	RK9 x Vaibhav	35.00	19.00	27.00	125.67	101.00	113.33
59.	RK14 xVaibhav	39.33	21.00	30.17	132.34	105.66	119.00
60.	KRV 47 xVaibhav	36.00	19.33	27.67	127.00	102.34	114.07

Table 11c: Contd.

S.N.	Crosses	Relative water content			Leaf water potential		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	77.37	39.50	58.43	11.50	14.50	13.10
2.	RK8602 x Mathura Rai	80.33	41.00	60.67	14.70	18.60	16.70
3.	RK8604 x Mathura Rai	93.10	47.53	70.32	10.20	13.00	11.60
4.	RK8605 x Mathura Rai	74.50	38.03	56.27	19.80	25.10	22.40
5.	RK8608 x Mathura Rai	78.40	40.03	59.22	15.00	19.00	17.00
6.	RK8701 x Mathura Rai	76.37	38.97	57.67	13.10	16.60	14.90
7.	RK8702 x Mathura Rai	83.73	42.73	63.23	11.40	14.50	13.00
8.	RK8801 x Mathura Rai	85.60	43.67	64.03	15.00	19.00	17.00
9.	RK8802 x Mathura Rai	92.53	47.20	69.87	18.00	22.80	20.40
10.	RK8803 x Mathura Rai	77.03	39.30	58.17	11.30	14.40	12.80
11.	RK8901 x Mathura Rai	81.43	41.53	61.48	13.40	17.00	15.20
12.	RK8902 x Mathura Rai	87.93	44.63	66.08	20.00	25.40	22.70
13.	RK8903 x Mathura Rai	91.43	46.67	69.05	10.40	13.20	11.80
14.	RL9001 x Mathura Rai	86.77	44.27	65.52	13.00	16.40	14.70
15.	RK9002 x Mathura Rai	88.33	45.10	66.72	15.20	19.30	17.30
16.	RK918506 x Mathura Rai	90.93	46.40	66.67	08.80	11.10	09.90
17.	RK911296 x Mathura Rai	94.10	48.03	71.07	16.40	20.70	18.60
18.	RK9 x Mathura Rai	85.57	43.67	64.62	15.10	19.30	17.20
19.	RK14 x Mathura Rai	97.97	49.97	73.97	11.60	14.70	13.20
20.	KRV 47 x Mathura Rai	77.73	39.67	58.70	14.70	18.60	16.60
21.	RK8601 x Laha 101	93.93	47.93	70.93	13.60	17.20	15.40
22.	RK8602 x Laha 101	91.50	46.90	69.20	13.50	17.00	15.20
23	RK8604 x Laha 101	78.40	40.00	59.20	16.40	20.80	18.60
24	RK8605 x Laha 101	78.80	40.20	59.50	10.30	13.00	11.60
25	RK8608 x Laha 101	91.47	46.70	69.08	15.20	19.20	17.20
26.	RK8701 x Laha 101	88.27	45.03	66.65	11.70	14.80	13.20
27.	RK8702 x Laha 101	80.43	41.03	60.73	14.70	18.70	16.70
28.	RK8801 x Laha 101	91.43	46.63	69.03	16.40	20.80	18.60
29.	RK8802 x Laha 101	86.53	44.17	69.35	16.70	21.10	18.90
30.	RK8803 x Laha 101	78.23	40.07	59.15	16.30	20.60	18.50
31.	RK8901 x Laha 101	83.53	42.63	63.08	16.60	21.10	10.80
32.	RK8902 x Laha 101	81.53	46.70	64.12	08.60	10.90	09.80
33.	RK8903 x Laha 101	78.30	39.97	59.13	17.90	22.60	20.30
34.	RL9001 x Laha 101	92.33	47.13	69.73	13.10	16.60	14.80
35.	RK9002 x Laha 101	76.07	38.80	57.43	08.50	10.80	09.70
36.	RK918506 x Laha 101	87.77	44.80	66.28	11.50	14.60	13.00
37.	RK911296 x Laha 101	82.27	41.97	62.12	10.20	12.90	11.60
38.	RK9 x Laha 101	77.47	39.53	58.50	11.40	14.50	13.00
39.	RK14 x Laha 101	76.47	39.00	57.73	14.70	18.60	16.70
40.	KRV 47 x Laha 101	82.47	42.10	62.28	19.70	24.30	22.00
41.	RK8601 xVaibhav	92.27	47.07	69.67	08.50	10.80	09.70
42.	RK8602 xVaibhav	95.15	48.57	71.85	18.30	23.20	20.80
43.	RK8604 xVaibhav	78.50	40.07	59.28	21.10	26.70	23.90
44	RK8605 xVaibhav	85.10	43.43	64.27	18.10	23.00	20.60
45.	RK8608 xVaibhav	81.21	41.43	61.32	13.10	16.60	14.90
46.	RK8701 xVaibhav	85.80	38.70	57.25	16.40	20.80	18.60
47.	RK8702 xVaibhav	82.13	41.93	62.03	13.00	16.50	14.80
48.	RK8801 xVaibhav	78.37	40.00	59.18	11.40	14.50	13.00
49.	RK8802 xVaibhav	86.33	44.07	65.20	11.80	14.90	13.30
50.	RK8803 xVaibhav	84.90	43.33	64.12	11.50	14.60	13.10
51.	RK8901 xVaibhav	92.03	46.97	69.50	21.40	27.10	24.30
52.	RK8902 xVaibhav	76.27	38.90	57.58	11.80	14.90	13.30
53.	RK8903 xVaibhav	87.53	44.67	66.10	11.40	14.40	12.90
54.	RL9001 xVaibhav	83.80	42.77	63.28	11.70	14.90	13.30
55.	RK9002 xVaibhav	91.43	46.63	69.03	12.90	15.00	14.00
56.	RK918506 xVaibhav	87.30	44.57	65.93	10.30	13.00	11.60
57.	RK911296 xVaibhav	91.00	46.43	68.72	14.80	17.70	16.20
58.	RK9 x Vaibhav	94.00	47.97	70.98	15.20	19.30	17.30
59.	RK14 xVaibhav	80.50	41.07	60.78	11.70	14.20	13.00
60.	KRV 47 xVaibhav	86.07	43.90	64.98	13.30	16.90	15.10

Table 11c: Contd.

S.N.	Crosses	Yield per plant			Oil content		
		E_1	E_2	Pooled	E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	55.33	25.67	35.50	43.00	30.01	36.57
2.	RK8602 x Mathura Rai	36.33	20.33	28.33	38.50	27.92	33.21
3.	RK8604 x Mathura Rai	44.67	25.33	35.00	42.06	29.58	35.82
4.	RK8605 x Mathura Rai	55.33	31.67	43.50	39.00	28.15	33.57
5.	RK8608 x Mathura Rai	40.67	23.00	31.83	33.55	25.62	29.59
6.	RK8701 x Mathura Rai	32.00	18.33	25.17	32.43	25.10	28.76
7.	RK8702 x Mathura Rai	42.67	24.33	33.50	40.21	28.72	34.47
8.	RK8801 x Mathura Rai	46.67	26.67	36.67	48.68	28.01	33.35
9.	RK8802 x Mathura Rai	43.33	24.67	34.00	37.47	27.44	32.45
10.	RK8803 x Mathura Rai	35.33	20.00	27.67	38.72	28.49	34.10
11.	RK8901 x Mathura Rai	29.67	17.00	23.33	41.52	29.32	35.42
12.	RK8902 x Mathura Rai	40.67	23.00	31.83	36.49	26.52	31.50
13.	RK8903 x Mathura Rai	29.33	16.67	23.00	49.94	28.59	34.27
14.	RL9001 x Mathura Rai	28.33	16.00	22.17	37.83	27.27	32.55
15.	RK9002 x Mathura Rai	48.67	25.33	35.00	38.46	27.90	33.18
16.	RK918506 x Mathura Rai	67.00	38.00	52.50	37.33	27.38	32.35
17.	RK911296 x Maathura Rai	38.67	22.00	30.33	42.06	29.58	35.82
18.	RK9 x Mathura Rai	84.33	47.67	66.00	39.63	28.45	34.04
19.	RK14 x Mathura Rai	38.33	21.67	30.00	40.03	28.64	34.33
20.	KRV 47 x Mathura Rai	70.33	40.00	55.17	42.91	29.98	36.44
21.	RK8601 x Laha 101	47.33	27.00	37.17	38.41	27.88	33.15
22.	RK8602 x Laha 101	67.33	35.00	48.17	40.93	29.05	34.99
23	RK8604 x Laha 101	44.33	25.00	34.67	39.00	28.15	33.58
24	RK8605 x Laha 101	57.67	32.67	45.17	37.24	27.34	32.29
25	RK8608 x Laha 101	30.33	17.33	23.83	40.71	28.95	34.83
26.	RK8701 x Laha 101	48.67	27.67	38.17	40.21	28.72	34.47
27.	RK8702 x Laha 101	28.00	16.00	22.00	38.28	27.82	33.05
28.	RK8801 x Laha 101	38.00	21.67	29.83	38.73	28.63	33.38
29.	RK8802 x Laha 101	37.00	21.00	29.00	41.97	29.53	35.75
30.	RK8803 x Laha 101	27.67	15.67	21.67	37.65	27.52	32.59
31.	RK8901 x Laha 101	40.33	23.00	31.67	42.10	29.60	35.85
32.	RK8902 x Laha 101	31.00	17.67	24.33	36.03	26.77	31.40
33.	RK8903 x Laha 101	45.33	26.00	35.67	37.65	27.53	32.59
34.	RL9001 x Laha 101	49.00	27.67	38.33	37.65	27.52	32.59
35.	RK9002 x Laha 101	48.33	27.33	37.83	37.83	27.61	32.72
36.	RK918506 x Laha 101	56.00	31.67	43.83	42.82	29.93	36.38
37.	RK911296 x Laha 101	35.00	20.00	27.50	39.27	28.28	33.77
38.	RK9 x Laha 101	37.67	21.33	29.50	40.57	28.89	34.73
39.	RK14 x Laha 101	26.33	14.67	20.50	40.34	28.78	34.56
40.	KRV 47 x Laha 101	29.00	16.33	22.67	36.12	26.81	31.46
41.	RK8601 xVaibhav	28.00	15.67	21.83	43.86	30.41	37.13
42.	RK8602 xVaibhav	26.67	15.00	20.83	39.85	28.55	34.20
43.	RK8604 xVaibhav	27.67	16.67	22.17	35.49	26.52	31.00
44	RK8605 xVaibhav	28.67	16.33	22.50	35.08	26.33	30.71
45.	RK8608 xVaibhav	26.67	15.00	20.83	40.66	28.93	34.79
46.	RK8701 xVaibhav	25.67	14.33	20.00	35.04	26.31	30.68
47.	RK8702 xVaibhav	26.00	15.00	20.50	40.44	28.82	34.63
48.	RK8801 xVaibhav	28.33	16.33	22.33	42.37	29.73	36.05
49.	RK8802 xVaibhav	27.33	15.67	21.50	40.66	28.93	34.79
50.	RK8803 xVaibhav	26.00	14.33	20.17	39.18	28.24	33.71
51.	RK8901 xVaibhav	26.00	14.67	20.33	35.58	26.56	31.07
52.	RK8902 xVaibhav	23.67	13.33	18.50	36.66	27.06	31.86
53.	RK8903 xVaibhav	25.33	14.33	19.83	37.33	27.38	32.36
54.	RL9001 xVaibhav	26.67	15.00	20.83	36.21	26.85	31.53
55.	RK9002 xVaibhav	24.33	13.67	19.00	43.68	30.33	37.00
56.	RK918506 xVaibhav	24.00	13.67	18.83	40.26	28.74	34.50
57.	RK911296 xVaibhav	24.00	13.67	18.83	36.07	26.79	31.43
58.	RK9 x Vaibhav	26.67	15.00	20.83	40.58	28.89	34.73
59.	RK14 xVaibhav	25.67	14.33	20.00	39.49	25.32	32.41
60.	KRV 47 xVaibhav	28.33	16.00	22.17	39.40	26.48	30.94

Table 11c: Contd.

S.N.	Crosses	Erucic acid		
		E_1	E_2	Pooled
1.	RK8601 x Mathura Rai	50.22	49.77	50.84
2.	RK8602 x Mathura Rai	50.22	51.15	50.84
3.	RK8604 x Mathura Rai	50.22	51.15	50.84
4.	RK8605 x Mathura Rai	50.22	50.84	50.53
5.	RK8608 x Mathura Rai	50.22	51.15	50.84
6.	RK8701 x Mathura Rai	50.22	50.84	50.53
7.	RK8702 x Mathura Rai	50.22	51.15	50.84
8.	RK8801 x Mathura Rai	50.22	51.46	50.84
9.	RK8802 x Mathura Rai	50.22	50.84	50.53
10.	RK8803 x Mathura Rai	50.53	50.84	50.84
11.	RK8901 x Mathura Rai	50.84	50.84	50.84
12.	RK8902 x Mathura Rai	50.84	50.84	50.84
13.	RK8903 x Mathura Rai	50.22	51.15	50.53
14.	RL9001 x Mathura Rai	50.53	51,15	50.84
15.	RK9002 x Mathura Rai	50.84	51.15	51.15
16.	RK918506 x Mathura. Rai	50.53	50.84	50.84
17.	RK911296 x Mathura Rai	50.84	50.84	50.84
18.	RK9 x Mathura Rai	50.22	50.15	50.53
19.	RK14 x Mathura Rai	50.22	51.15	50.53
20.	KRV 47 x Mathura Rai	50.53	51.15	50.84
21.	RK8601 x Laha 101	50.84	51.15	51.15
22.	RK8602 x Laha 101	50.22	50.84	50.53
23	RK8604 x Laha 101	50.53	50.84	50.84
24	RK8605 x Laha 101	50.53	50.84	50.84
25	RK8608 x Laha 101	50.22	51.15	50.84
26.	RK8701 x Laha 101	50.22	51.15	50.84
27.	RK8702 x Laha 101	50.53	51.15	50.84
28.	RK8801 x Laha 101	50.53	50.84	50.84
29.	RK8802 x Laha 101	50.22	51.15	50.84
30.	RK8803 x Laha 101	50.22	50.84	50.53
31.	RK8901 x Laha 101	50.22	52.51	50.53
32.	RK8902 x Laha 101	50.53	50.84	50.84
33.	RK8903 x Laha 101	50.53	51.15	50.84
34.	RL9001 x Laha 101	50.53	50.84	50.53
35.	RK9002 x Laha 101	50.22	51.15	50.53
36.	RK918506 x Laha 101	50.22	50.84	50.53
37.	RK911296 x Laha 101	50.53	50.82	50.84
38.	RK9 x Laha 101	50.53	51.15	50.84
39.	RK14 x Laha 101	50.84	50.84	50.84
40.	KRV 47 x Laha 101	50.84	50.84	50.84
41.	RK8601 xVaibhav	50.53	50.84	50.53
42.	RK8602 xVaibhav	50.53	50.84	50.53
43.	RK8604 xVaibhav	50.84	51.15	51.15
44	RK8605 xVaibhav	50.84	51.15	51.15
45.	RK8608 xVaibhav	50.22	51.15	50.84
46.	RK8701 xVaibhav	50.22	51.15	50.84
47.	RK8702 xVaibhav	50.22	51.15	50.84
48.	RK8801 xVaibhav	50.22	51.15	50.84
49.	RK8802 xVaibhav	50.22	51.15	50.84
50.	RK8803 xVaibhav	50.53	51.15	50.84
51.	RK8901 xVaibhav	50.22	50.84	50.84
52.	RK8902 xVaibhav	50.22	50.84	50.53
53.	RK8903 xVaibhav	50.53	50.84	50.84
54.	RL9001 xVaibhav	50.84	51.15	51.15
55.	RK9002 xVaibhav	50.84	51.15	51.15
56.	RK918506 xVaibhav	50.84	51.15	51.15
57.	RK911296 xVaibhav	50.84	50.84	50.84
58.	RK9 x Vaibhav	50.84	50.84	50.84
59.	RK14 xVaibhav	50.53	51.15	50.84
60.	KRV 47 xVaibhav	50.53	51.15	50.84